

A REVISION OF LATE ORDOVICIAN BIVALVES FROM POMEROY, CO. TYRONE, IRELAND

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ABSTRACT. A history of research on Ordovician bivalves from Pomeroy is given, and their stratigraphic distribution in the Caradoc-Ashgill rocks is outlined. More than thirty taxa are described including five new species: *Praenucula dispersa*, *P. infirma*, *P. praetermissa*, *Ambonychia arundinea*, and *Cleionychia incognita*. The rostroconch *Hippocardia praeprestis* (Reed) is illustrated.

SINCE Portlock (1837, 1843) first described the faunas of the Caradoc-Ashgill rocks of the Pomeroy area of County Tyrone (text-fig. 1), some elements have been studied thoroughly, especially the trilobites and brachiopods, which have helped to show the relationship of the Pomeroy strata to the Ordovician of North America and southern Scotland (Mitchell, 1977, and others). Although molluscs are abundant in the rocks of Pomeroy, they have received scant attention in recent years. The orthoconic nautiloids were redescribed by Blake (1882) but have remained unrevised since; the gastropods have been described by Longstaff (=Donald) (1902, 1924) and Reed (1952). The bivalves were largely ignored until Reed (1952) redescribed Portlock's species and added a number of new taxa. Reed was unaware of Portlock's many duplicate specimens, including syntypes, now housed in the Ulster Museum (Tunnicliff 1980), and did not have the benefit of collections made in recent years by the Geological Survey of Northern Ireland, by Dr. W. I. Mitchell and by Mr. R. P. Tripp and others of the British Museum (Natural History). With the aid of this new material a critical re-examination of the bivalve fauna has been carried out and several new forms have been recognized.

History of Pomeroy bivalve research

Portlock (1843) mentioned or described in varying detail the following species, arranged here according to the formation from which they can now be recognized to have come.

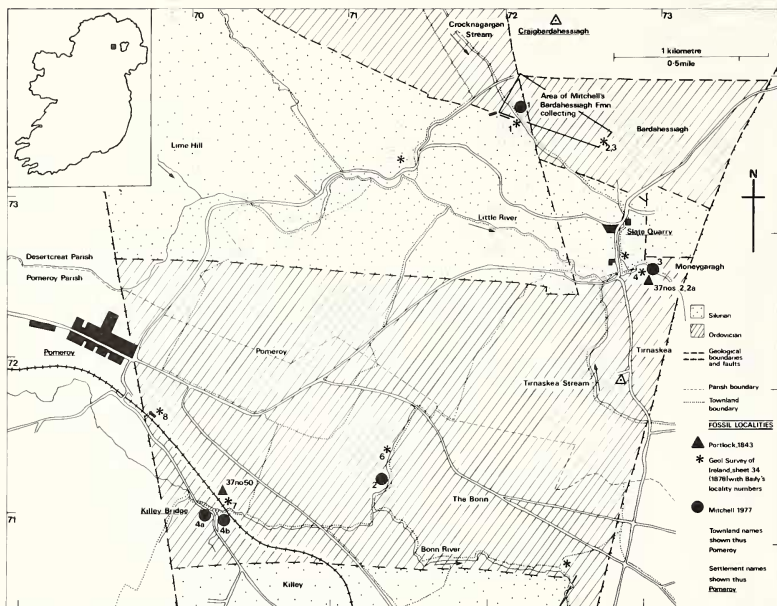
Baradahessiagh Formation (Caradoc):

<i>Avicula obliqua</i> Murchison	<i>Modiola securiformis</i> Portlock
<i>Avicula orbicularis</i> Murchison	<i>Inoceramus priscus</i> Portlock
<i>Modiola Brycei</i> Portlock	<i>Inoceramus transversus</i> Portlock
<i>Modiola expansa</i> Portlock	<i>Inoceramus trigonus</i> (Münster)
<i>Nucula Nerei</i> (Münster)	<i>Nucula radiata</i> Portlock

Killey Bridge Formation (Ashgill, Cautleyan):

<i>Inoceramus contortus</i> Portlock	<i>Arca subtruncata</i> Portlock
<i>Cypriocardia simplex</i> Portlock	<i>Arca transversa</i> Portlock
<i>Arca cylindrica</i> Portlock	<i>Pectunculus ambiguus</i> Portlock
<i>Arca dissimilis</i> Portlock	<i>Pectunculus Apjohni</i> Portlock
<i>Arca Eastnori</i> (Murchison)	<i>Pectunculus semitruncatus</i> Portlock
<i>Arca obliqua</i> Portlock	<i>Nucula acuta</i> ? (Sowerby) var. <i>imbricata</i> Portlock
<i>Arca regularis</i> Portlock	<i>Uncites gryphus</i> Schlotheim var.

In addition to these, Portlock had a number of specimens to which he did not refer in print but to which he fixed labels with suggested identifications and observations. Notes on how Portlock labelled his specimens are given by Tunnicliff (1980). His *Mytilus cinctus* Portlock and *Posidonomya? venusta* (Münster) are from rocks of Llandovery age as is his *Mytilus? semi-rugatus* Portlock from Lisbellaw, Co. Fermanagh. Portlock's



TEXT-FIG. 1. The area around Pomeroy, Co. Tyrone, based on Mitchell 1977 (taken from Tunnicliff 1980), with Ireland inset to show the position of Pomeroy.

figures, although generally of natural size, often lack the detail which might be expected in modern illustrations. Many of his descriptions contain useful detail such as height and length of valves and the number of teeth visible, but others are less helpful.

Describing specimens from the collection of Sir R. Griffith, McCoy (1846) added the following species from the Bardaheessagh Formation, *Pullastra speciosa* McCoy and from the Killey Bridge Formation, *Nucula protei* Münster, *N. subacuta* McCoy, *Arca quadrata* McCoy.

In 1878 (p. 28) Bailey published a list of Portlock bivalve species giving amended generic names and gave a list (p. 25) of the species collected by officers of the Geological Survey of Ireland during the survey of the 1870s.

Apart from some brief discussion by Hind (1910), Bailey's was the last contribution to the study of Pomeroy Ordovician bivalves before the publication of Reed's posthumous paper in 1952. In this Reed redescribed most of Portlock's species and added the following:

Ctenodonta perangulata Reed
Ctenodonta deserti Reed
Ctenodonta cf. nitida (Ulrich)
Clidophorus occultus Reed
Vanuxemia? suspecta Reed
Modiolopsis concentrica simulans Reed
Orthodesma tyronense Reed
Conocardium praeprestis Reed

Paramodiola? sp.
Whiteavesia subexpansa Reed
Ambonychia cf. volvens Isberg
Ambonychia cf. amygdalina (Hall)
Ambonychia cf. intermedia Isberg
Clionychia subovalis Reed
Clionychia subquadrata Reed

Horizons and localities (Text-figs. 1 and 2)

The Ordovician stratigraphy of Pomeroy was discussed by Mitchell (1977, pp. 4-18). Bivalves are recorded from the following strata:

- Tirnaskea Formation (Ashgill, Hirnantian)
- Killey Bridge Formation (Ashgill, Cautleyan)
- Bardahessiagh Formation (Caradoc).

No bivalves are recognized as being from Mitchell's Junction beds.

The horizon of Portlock specimens and other material from old collections is inferred from the lithologies and from the known locality information (see Tunnicliff 1980).

The localities of many of the specimens in the old collections are uncertain, often given only as 'Pomeroy'. However, by comparison with material in the recent well-localized collections and with the small number of likely sites, it is possible to suggest localities for most specimens, usually with reference to those listed by Mitchell (1977, pp. 5-7). Portlock's localities are discussed by Tunnicliff (1980).

Stratigraphic distribution (Table 1)

The bivalve fauna of the Bardahessiagh Formation is dominated by cyrtodontids and ambonychiids, the former probably infaunal or semi-infaunal, the latter epifaunal and byssate. *Cyrtodonta?* often occurs as conjoined valves suggestive of little or no transport after death. The other infaunal genera represented in the Bardahessiagh Formation are *Praenucula*, *Deceptrix*, *Similodonta?*, and *Lyrodesma* all of which are uncommon compared with *Cyrtodonta?*. *Similodonta?* and *Lyrodesma* both occur as conjoined or closely associated valves

SERIES & Stage	Graptolite zone	Pomeroy	Girvan	Bohemia	North America
ASHGILL Hirnantian		Tirnaskea Formation	High Mains	Kosov Formation	
Rawtheyan					
Cautleyan	<i>D. anceps</i>	Killey Bridge Formation	Drummuck Group	Králův Dvůr Formation	d5 Richmondian
Pusgillian	<i>D. complanatus</i>		Shalloch Formation		
CARADOC Onnian	<i>P. linearis</i>		Whitehouse Group		d4 Edenian
Actonian					
Marshbrookian				Bohdalec Formation	
Woolstonian	<i>D. clingani</i>	Junction Beds	Ardwell Group		Shermanian
Longvillian		Bardahessiagh Formation			
Soudleyan	<i>C. wilsoni</i>			Zahořany F. Vínice F.	d3
Harnagian	<i>C. peltifer</i>		Bakclatchie	Letná Formation	d2 Wildernessian
Costonian	<i>N. gracilis</i>				

TEXT-FIG. 2. Approximate correlation of the Ordovician rocks of Pomeroy based on Williams *et al.* (1972), Mitchell (1977), and R. P. Tripp and J. K. Ingham (pers. comm. 1981). The approximate stratigraphic equivalents of Barrande's stages d₂, d₃, d₄, and d₅ in Bohemia are shown (based on Kříž and Pojeta 1974).

TABLE 1. The stratigraphic distribution of bivalves from the Ordovician rocks of Pomeroy, Co. Tyrone

	Bardahessiagh Formation	Killey Bridge Formation	Tirnaskea Formation
<i>Praenucula dispersa</i> sp. nov.	x		
<i>P. praetermissa</i> sp. nov.		x	
<i>P. aff. praetermissa</i> sp. nov.		x	
<i>P. infirma</i> sp. nov.		x	
<i>Deceptrix</i> sp.	x		
<i>D. apjohnni</i> (Portlock)		x	
<i>D. regularis</i> (Portlock)		x	
<i>D. semitruncata</i> (Portlock)		x	
<i>D. subtruncata</i> (Portlock)		x	
<i>Similodonta?</i> sp.	x		
<i>Concavodonta imbricata</i> (Portlock)		x	
<i>Nuculites cylindricus</i> (Portlock)		x	
<i>Nuculoid</i> gen. and sp. nov.			x
<i>Cyrtodonta? expansa</i> (Portlock)	x		
<i>C.? securiformis</i> (Portlock)	x		
<i>C.? sp.</i>	x		
<i>Vanuxemia contorta</i> (Portlock)		x	
<i>Ambonychia arundinea</i> sp. nov.		x	
<i>Cleionychia transversa</i> (Portlock)	x		
<i>C. prisca</i> (Portlock)	x		
<i>C. incognita</i> sp. nov.	x		
<i>Ambonychiopsis suspecta</i> (Reed)	x		
pterineid? gen. and sp. indet.		x	
? bivalve gen. and sp. indet.	x		
<i>Modiolopsis</i> sp.		x	
<i>Corallidomus concentrica</i> (Hall and Whitfield)		x	
<i>Corallidomus? sp.</i>		x	
<i>Goniophora</i> sp.		x	
<i>Colpomya simplex</i> (Portlock)		x	
<i>Semicorallidomus?</i> sp.	x		
<i>Cycloconcha? speciosa</i> (McCoy)	x		
<i>Lyrodesma radiatum</i> (Portlock)	x		
<i>Hippocardia praepristis</i> (Reed)		?	

but, like *Cyrtodonta?*, are never suggestive of life position but rather of having been winnowed out from the substrate. Of the epifaunal ambonychiids, *Cleionychia* is best represented, and some also occur as conjoined valves. The nature of the present-day Bardahessiagh Formation exposure (Mitchell 1977, p. 5) precludes identifying the exact localities for most specimens.

In the Killey Bridge Formation the principal elements of the bivalve fauna are infaunal nuculoids, *Praenucula*, *Deceptrix*, *Concavodonta*, and *Nuculites*. These are all numerous compared with other genera, most of which are represented in the collections by only one or two specimens. Most specimens from the Killey Bridge Formation are single valves, but conjoined valves of all nuculoid genera are present. Bivalves are recorded from all the localities where the Killey Bridge Formation is represented by dark-grey calcareous mudstone (e.g. localities 1-3 of Mitchell 1977) but determinable bivalves are not known from the rottenstone and sandstone lens recorded by Mitchell (localities 4a, b of Mitchell 1977) in which brachiopods are abundant and varied.

Determinable bivalves are also almost unknown from the Tirnaskea Formation; only *Nuculoid* gen. nov. and the rostroconch *Hippocardia* (by Reed 1952) are recorded and the latter is more probably from the Killey Bridge Formation. Mitchell (1977, p. 17) compared the Tirnaskea fauna with the Hirnantian *Hirnantia* fauna.

The differences between the Bardahessiagh and Killey Bridge bivalve faunas are a reflection of their differing palaeoenvironments; the generally sandy Bardahessiagh Formation probably represents a shallow-shelf environment favouring the modes of life of cyrtodontids and ambonychiids, while the mudstones of the Killey Bridge Formation were probably the product of a more stable deeper-shelf environment. The Bardahessiagh Formation bivalve fauna has a distinctly eastern American aspect which is less obvious, but still present in the Killey Bridge Formation.

SYSTEMATIC PALAEONTOLOGY

In general, the classification used in the *Treatise of Invertebrate Palaeontology*, N1 and 2 (Moore 1969) is adopted. Where this is deviated from is stated in this text, and the author whose precedent is followed is given.

Measurements. In some cases tables of measurements are given in which the terms mean and median are used. Mean is used to show the sum of the items divided by the number of items; median is used to convey the mid-point between the maximum and minimum values of a group of items. All linear measurements are given in millimetres (mm), measured with a vernier caliper or under a binocular microscope with a graticule. Abbreviations used are L for length, H for height, AL for preumbonal length. In tables of measurements, the term 'angle' is used for the angle between the anterior and posterior hinge-plates in nuculoids.

Preservation. Two terms used require a note of explanation. Composite mould is used in the sense of McAlester 1962. External cast is used to describe a naturally occurring convex specimen which shows only external features but which has probably been produced in a similar manner to composite moulds.

This study is based on material in the following museums: Institute of Geological Sciences (IGS), British Museum (Natural History) (BM), Sedgwick Museum, Cambridge (SM), Ulster Museum, Belfast (UM), National Museum of Ireland, Dublin (NMI).

Class BIVALVIA Linnaeus, 1758

Subclass PALAEOXODONTA Korobkov, 1954

Order NUCULOIDEA Dall, 1889

Superfamily NUCULACEA Gray, 1824

Family PRAENUCULIDAE Pfab, 1934

Remarks. Three genera of Praenuculids are certainly recognized from Pomeroy: *Praenucula* and *Deceptrix* from the Bardahessiagh and Killey Bridge Formations and *Concavodonta* from the Killey Bridge Formation. *Concavodonta* is distinct from the other two genera (see discussion of *Concavodonta*) but *Praenucula* and *Deceptrix* are less easily distinguished at first sight. Pojeta (1971, p. 16) implied that they were synonymous ('... some authors recognize *Praenucula* Pfab as being distinct from *Deceptrix* ...'). Pojeta, Kříž, and Berdan (1976) treated *Praenucula* as a subgenus of *Deceptrix*. McAlester (1969, p. 229), placed Pfab's *Praeleda* in synonymy with *Deceptrix* and both have been used for species which show the characters of *Praenucula*, for example *Praeleda ciae* (Sharpe) of Bradshaw 1970, and *Deceptrix* cf. *ciae* (Sharpe) of Babin and Robardet 1973. *Praenucula* and *Deceptrix* have remained virtually unused in the British Ordovician and I can find no reference to their occurrence in the British Isles, except *Praenucula* from the Arenig of Ramsey Island (Carter 1971, p. 251). Specimens from British localities which could now be placed in *Praenucula* or *Deceptrix* have usually been recorded as *Ctenodonta*, often under open nomenclature.

In the species discussed here, distinction is made between *Praenucula* and *Deceptrix* principally on the differences indicated by McAlester (1969, p. 229); that is that the posterior teeth in *Deceptrix* are smaller and more numerous than the anterior teeth, while in *Praenucula* the anterior and posterior teeth are similar in size and number. To this we may add that the umbones in *Praenucula* lie in the posterior half while in *Deceptrix* they generally lie in the anterior half. Corresponding to the greater posterior length in *Deceptrix* is the relatively greater length (equal to or longer than the anterior) of its posterior hinge-plate. In *Praenucula* the posterior hinge-plate is equal to or shorter in length than the anterior hinge-plate. In both genera the anterior hinge-plate is arched towards the body of the shell and the posterior hinge-plate is straight or gently arched away from the body of the shell. The adductor muscle scars in both genera are equal or subequal but their

relative sizes and positions differ, being larger and more ventral in *Deceptrix* (Pls. 7-9). In *Praenucula* the adductor muscle scars are close to, and may extend beyond, the ends of the hinge-plates, while in *Deceptrix* the posterior scar lies closer to the umbo, only extending as far as the end of the hinge-plate, and the anterior scar lies in the most anterior part of the shell, beyond the end of the hinge-plate.

A fourth genus, *Similodonta*, may be represented by specimens from the Bardahessiagh Formation.

Genus *PRAENUCULA* Pfab, 1934

Type species. By original designation of Pfab 1934, pp. 234-235, *Praenucula dispar expansa* Pfab, 1934, from the Šárka Formation (Llanvirn) of Bohemia (Havlíček and Vaněk 1966) and described and figured by McAlester (1968, p. 46, pl. 8, figs. 3-9). See discussion under Praenuculidae above.

Praenucula dispersa sp. nov.

Plate 7, figs. 1-5; text-fig. 3a

Derivation of name. From Latin *dispersus* scattered, referring to the occurrence in loose blocks.

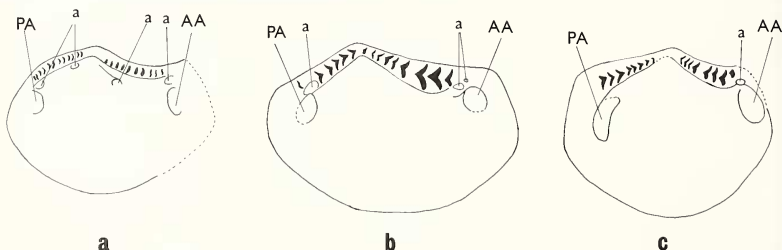
Type specimens. Holotype IGS GU 1893, internal mould of right valve, and paratypes IGS GU 1354, 1894, 1897, 1906, 3265, UM K4203, SM A16296, 3 left and 4 right valves; one a composite mould, the remainder internal moulds.

Horizon and locality. All specimens are from the Bardahessiagh Formation; GU specimens from the area of Mitchell's Bardahessiagh Formation collecting (Mitchell 1977), the others from uncertain localities to the south of Craigbardahessiagh.

Measurements

	L	H	H/L	AL/L	Angle
Max.	13.2 mm	11.0 mm	0.87	0.65	155°
Min.	7.8 mm	6.8 mm	0.61	0.50	130°
Mean	10.62 mm	8.15 mm	0.77	0.50	145°
Median	10.5 mm	8.9 mm	0.74	0.58	142.5°

Description. Ovate *Praenucula* with height about 0.7 of the length but variable. Umbo slightly posterior of centre, between the posterior two-fifths and mid-point, and extending slightly above the hinge-line. Convexity greatest slightly anterior to the umbo, maximum inflation of a single valve 2.4 mm seen in a valve 11 mm



TEXT-FIG. 3. *Praenucula* spp. based on internal moulds, *c.* $\times 5$. (a) *P. dispersa* sp. nov., IGS GU 1906, right valve. (b) *P. infirma* sp. nov., IGS NIL 8935, right valve. (c) *P. praetermissa* sp. nov., IGS NIL 8757, latex of left valve. Abbreviations: AA— anterior adductor muscle scar, PA— posterior adductor muscle scar, a— accessory muscle scar. Compare with Pl. 7, figs. 5, 12, 21. Note the differences in size of the adductor muscle scars and the differences in the size of the teeth and in their distribution on either side of the umbo. In each case, the finest teeth below the umbo are too small to be represented clearly.

long and 8 mm high. Angle between anterior and posterior hinge-plates about 140 to 145°. Posterior hinge-plate straight with 12+ uniformly sized teeth. Anterior hinge-plate concave towards the body of the shell, with 13+ teeth, increasing in size forwards. Slightly chevron-shaped teeth passing beneath umbo in a continuous series, chevrons directed towards the umbo. Anterior and posterior muscle scars clearly distinguished, equal in size the anterior more deeply impressed than the posterior and most deeply impressed at its posterior edge. Accessory muscles known (text-fig. 3a). Ligament and shell material unknown. Sculpture of fine concentric lines (c. 4 per mm) (Pl. 7, fig. 3).

Discussion. Nuculoid bivalves are poorly represented in the Bardahessiagh Formation, and those that are found are not well preserved. In particular, the very soft nature of some of the rottenstone has led to damage to, or loss of, the hinge-plate and teeth. The deformation apparent in other species from the Bardahessiagh Formation (e.g. *Cyrtodonta?* spp.) appears to have produced some variation among the *Praenucula* specimens; however, it is reasonable to regard them as belonging to a single species.

Praenucula dispersa is distinguished from the Killey Bridge Formation species, *Praenucula praetermissa* and *P. infirma*, by having smaller, less strongly chevron-shaped teeth. In the same way it can be differentiated from *P. costae* (Sharpe) as described by Bradshaw (1970, pp. 630–633) from the Llandeilo of Finistère. *P. dispersa* has more teeth than *P. ciae* (Sharpe) (of Bradshaw 1970, pp. 633–636) and *Deceptrix pulchra armoricana* Babin and Melou (1972, pp. 81–82, pl. 8, figs. 4–7), and it lacks the posterior lobe seen in Hind's Drummuck species *Nuculana lobata* (1910, p. 519, pl. 4, figs. 1–3) and is less elongate than his *N. curta* (1910, p. 521, pl. 4, figs. 10–14) which is also from the Drummuck Group (Ashgill).

Ctenodonta albertina Ulrich and *C. filistriata* Ulrich (1894, pp. 598–599, pl. 42, figs. 76–82, text-fig. 44), both from the Cincinnati, have a pit beneath the umbo according to Ulrich's descriptions. Recent illustrations (Pojeta 1971, pl. 5, figs. 14–16; 1978, pl. 2, figs. 1–2) show a discontinuity in the dentition beneath the umbo not apparent in *P. dispersa*. *Nucula dispar* Barrande (1881, pl. 273, VII, figs. 1–14) is more rounded than *P. dispersa*.

Praenucula praetermissa sp. nov.

Plate 7, figs. 16, 21, 24; text-fig. 3c

Derivation of name. From the Latin *praetermittere*, to overlook, referring to the fact that the species has been overlooked by previous authors.

Type specimens. Holotype, IGS NIL 8757, composite mould of a left valve from the Killey Bridge Formation of the Crocknagargan Stream section (locality 1 of Mitchell 1977), Pomeroy, Co. Tyrone. Paratypes: 6 left and 6 right valves, internal, external, and composite moulds: IGS NIL 8687, 8747–8748, 8755, 8768, 8893, 8917, 8986, 8987 all from the same locality as the holotype; IGS NIG 482, Zs 2758 from locality 3 of Mitchell 1977, and IGS GU 1451 from his locality 2 (Warren Wood River). All from the Killey Bridge Formation.

Measurements	L	H	H/L	AL/L	Angle
Max.	11.0 mm	9.2 mm	0.83	0.70	160°
Min.	5.4 mm	3.6 mm	0.50	0.50	130°
Mean	8.6 mm	5.71 mm	0.72	0.60	143°
Median	8.2 mm	6.40 mm	0.66	0.60	145°

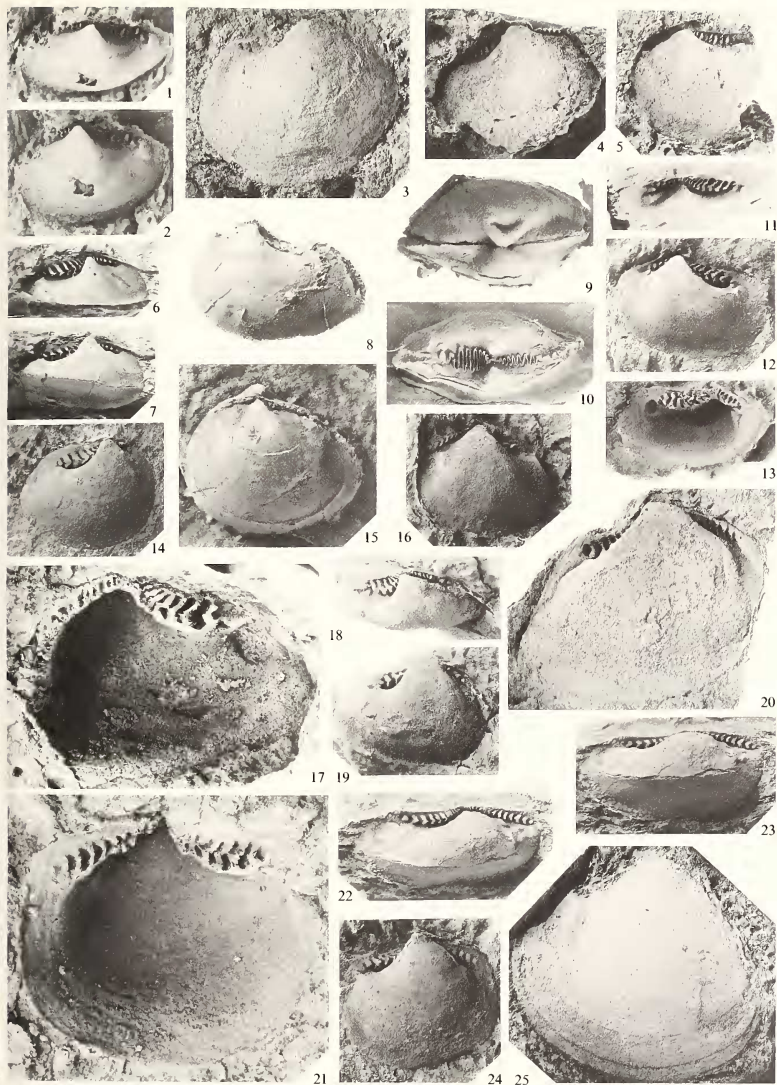
Description. Subovate to circular *Praenucula* in which the height is about 0.7 of the length. Maximum inflation of a single valve 1.4 mm seen in a valve 11.0 mm long and 9.2 mm high. The umbo is at about the posterior two-fifths. The shell is truncate behind and rounded in front. The anterior hinge-plate is broad and strongly arched towards the body of the shell. The anterior and posterior hinge-plates meet at an angle of about 145°, and usually bear the same number of teeth, up to nine. The teeth of the anterior hinge-plate are the larger and are strongly chevron-shaped; those of the posterior hinge-plate are markedly less so. The adductor muscle scars are subequal in size, the anterior scar being the more strongly impressed and lying below and slightly anterior to the anterior teeth with a diameter about one-quarter of the valve height; the posterior scar lies immediately below the end of the posterior dental series. Accessory muscle scars unknown, except for one anterior scar. Sculpture is of fine concentric lines, c. 16 per mm.

Discussion. This is a most distinctive form within the Pomeroy fauna, which, surprisingly, does not seem to have been seen by previous workers (Portlock, McCoy, Reed) and yet is well represented in recent collections, especially as fragments. *Praenucula praetermissa* is distinguished from *P. infirma*, described herein from the Killey Bridge Formation, by its larger adductor muscle scars and its more numerous posterior teeth, and from *P. dispersa* from the Bardahessiagh Formation by its larger and strongly chevron-shaped teeth. *P. praetermissa* lacks the lobate posterior of Hind's *Nuculana lobata* (1910, p. 519, pl. 4, figs. 1-3) and is less elongate than his *N. curta* (1910, p. 521, pl. 4, figs. 10-14), both from the Drummuck Group (Ashgill). It also lacks the pit beneath the umbo recorded in *N. curta* and in the American species *Ctenodonta albertina* Ulrich and *C. filistriata* Ulrich (1894, pp. 598-599, pl. 42, figs. 76-82, text-fig. 44).

It may be compared with other Ordovician *Praenucula* described from Europe: *Deceptrix pulchra armoricana* Babin and Melou, 1972 (= *D. cf. ciae* (Sharpe) of Babin and Robardet 1973) from the Caradocian rocks of Normandy, has a coarser sculpture than *P. praetermissa*, c. 6-8 lines per mm, grouped into 'faisceaux' (Babin and Melou 1972, p. 82, pl. 7, fig. 7). *Praeleda pulchra* Pfab, 1934, is recorded by Havlíček and Vaněk 1966, from the Llanvirn, Caradoc, and Ashgill of Bohemia, and in shape resembles *Praenucula praetermissa* (Pfab 1934, p. 234, pl. 3, fig. 6) but Pfab gave no detail of dentition or hinge, and no sculpture is evident in his figure. *Nucula costae* (Sharpe) from Portugal, according to Sharpe's description (1853, pp. 148-149, pl. 9, fig. 4a, b) has more teeth than *P. praetermissa*, about 20 (given as 25-30 at one point and as a total of about 18 elsewhere) divided unequally between posterior and anterior, and shows the grouping of concentric striae also described in *D. armoricana*. The forms described by Bradshaw (1970, pp. 630-633) as *Praeleda costae* (Sharpe) from the Llandeilo of Finistère are closer in most respects to *Praenucula praetermissa*.

EXPLANATION OF PLATE 7

- Figs. 1-5. *Praenucula dispersa* sp. nov. 1, 2, oblique dorsal view and lateral view, internal mould of right valve, holotype, IGS GU 1893. 3, ?composite mould of left valve, UM K4203. 4, internal mould of left valve, paratype, IGS GU 3265. 5, internal mould of right valve, paratype IGS GU 1906. All from the Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, Pomeroy, $\times 3$.
- Figs. 6-15, 17-19. *Praenucula infirma* sp. nov. 6, 7, oblique dorsal and lateral views, internal mould of left valve, IGS NIL 8824, Crocknagargan Stream section, Pomeroy (IGR c.H721737). 8, 15, internal mould and latex cast of external mould of right valve, IGS NIL 8682, 8682 *pars*, ditch exposure south of Craighbardahessiagh, Pomeroy (IGR H7195 7385). 9, 10, dorsal view of external mould and dorsal view of internal mould, conjoined valves, IGS NIL 8938, Crocknagargan Stream section, Pomeroy (IGR c.H721737). 11, 12, 13, dorsal and lateral views and latex cast of internal mould of right valve, holotype, IGS NIL 8935, Crocknagargan Stream section, Pomeroy (IGR c.H721737). 14, internal mould of left valve, IGS NIL 8754, Crocknagargan Stream section, Pomeroy (IGR c.H721737), $\times 3$. 17, 18, 19, internal mould of left valve, IGS NIL 8444, Tinaskea Stream section, Pomeroy (IGR c.H727725); 17, latex cast, $\times 6$; 18, oblique dorsal view, $\times 3$; 19, lateral view, $\times 3$. All Killey Bridge Formation (Ashgill, Cautleyan), $\times 3$.
- Figs. 16, 21, 24. *Praenucula praetermissa* sp. nov. 16, internal mould of right valve, IGS NIL 8917, Crocknagargan Stream section, Pomeroy (IGR c.H721737), $\times 3$. 21, 24, left valve internal mould, holotype, IGS NIL 8757, Crocknagargan Stream section, Pomeroy (IGR c.H721737); 21, latex cast, $\times 6$; 24, lateral view, $\times 3$. All Killey Bridge Formation (Ashgill, Cautleyan).
- Fig. 20. *Praenucula* aff. *praetermissa* sp. nov. internal mould of left valve, IGS NIL 8972, Killey Bridge Formation (Ashgill, Cautleyan), Crocknagargan Stream section, Pomeroy (IGR c.H721737), $\times 3$.
- Figs. 22, 23. *Praenucula* aff. *praetermissa* sp. nov. Oblique dorsal view and lateral view of crushed internal mould of left valve, IGS NIL 8934, Killey Bridge Formation (Ashgill, Cautleyan), Crocknagargan Stream section, Pomeroy (IGR c.H721737), $\times 3$.
- Fig. 25. *Similodonta?* sp., composite mould of left valve showing fine concentric ornament and anterior adductor muscle scar, UM K4241, Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, Pomeroy, $\times 3$.



TUNNICLIFF, Ordovician bivalves

but also tend to have more teeth (17–22) and no detail of the sculpture is given. *N. ciae* Sharpe (1853, p. 149, pl. 9 fig. 5a–c) from Portugal has a similar number of teeth (c. 19) and is described as having fine concentric lines like *P. praetermissa*. However, *P. praetermissa* differs from Bradshaw's (1970, pp. 633–636) *Praeleda ciae* (Sharpe) in the posterior teeth: in Bradshaw's *P. ciae* and in Babin's *Ctenodonta ciae* (Sharpe) (Babin 1966, pp. 49–52, text-fig. 11) the posterior chevron-shaped teeth seem to point away from the umbo, in *Praenucula praetermissa* the chevrons point towards the umbo. In this respect *P. praetermissa* resembles Sharpe's *N. ciae*.

A single internal mould of a large left valve (IGS NIL 8972; Pl. 7, fig. 20) from the Killey Bridge Formation of the Crocknagargan Stream Section is like *P. praetermissa* in shape, but is 16 mm long and 13 mm high with a maximum inflation of 4 mm. The hinge-plates meet at an angle of 145° with 13 anterior and 15 posterior teeth meeting below the umbo. Its musculature is indistinct and sculpture unknown. Because of its large size and more central umbo, it is here recorded as *P. aff. praetermissa*.

A second specimen (IGS NIL 8934; Pl. 7, figs. 22, 23) from the same horizon and locality is also recorded as *P. aff. praetermissa*. It is large, 11.8 mm long, but crushed dorso-ventrally. The umbo is at the mid-point and the hinge-plates meet at an angle of 165° with 12 anterior and 14 + posterior chevron-shaped teeth meeting below the umbo. The adductor muscle scars are round and equal in size, about one-quarter of the valve height in diameter and each is close below and slightly anterior to the end of the corresponding dental series. The sculpture is unknown. It differs from *P. praetermissa* in its more central umbo and in having more teeth corresponding to its large size.

The collections at IGS contain a specimen (IGS PT 9049) from the Corona Beds, Dufton Shales (Caradoc, Longvillian) which is comparable with both *P. praetermissa* and *P. pulchra armoricana*.

Praenucula infirma sp. nov.

Plate 7, figs. 6–15, 17–19; text-fig. 3b

Derivation of name. From the Latin *infirma*, weak, referring to the small size of the adductor muscle scars.

Type specimens. Holotype, IGS NIL 8935, an internal mould of a right valve, from the Killey Bridge Formation of the Crocknagargan Stream section (locality 1 of Mitchell 1977) Pomeroy, Co. Tyrone. Paratypes: 9 left and 5 right valves, internal, external, and composite moulds: IGS NIL 8754, 8772, 8824, 8828, 8938, 8952 all from the same locality as the holotype; IGS NIL 8444–8445 from the Tirnaskea Stream section; IGS Zs 2729, 2737–2738 from locality 3 of Mitchell 1977; IGS NIL 8682, 8682 *pars* from a ditch exposure at IGR H 7195 7385. All from the Killey Bridge Formation.

Measurements	L	H	H/L	AL/L	Angle
Max.	12.4 mm	9.0 mm	0.81	0.64	160°
Min.	8.6 mm	4.2 mm	0.49	0.54	120°
Mean	10.4 mm	6.2 mm	0.68	0.59	145.5°
Median	10.5 mm	6.6 mm	0.65	0.59	140°

Description. Transversely subovate *Praenucula* in which the posterior end is slightly rounded or subtruncate and the front is rounded or somewhat angular. The height is usually between 0.6 and 0.7 of the length. The umbo is at about the posterior two-fifths. Maximum inflation of a single valve 2.2 mm seen in a valve 11.6 mm long and 9.0 mm high. The highest part of the shell is a little anterior of the umbo. The hinge-plates meet at an angle of about 140–145°; the anterior hinge-plate is broad and arched ventrally and bears up to eleven large teeth, the posterior hinge-plate bearing up to nine which are smaller and less markedly chevron-shaped. The dental series meet below the umbo. The adductor muscle scars are of equal size, in diameter about one-eighth of the valve height; the anterior scar is anterior to the end of the anterior hinge-plate and lies at the same height as the ventral edge of the plate. The posterior scar lies immediately below the end of the posterior hinge-plate. Both scars are distinct and quite strongly impressed. At least two umbonal muscle scars present. Sculpture of fine concentric lines, c. 16 per mm.

Discussion. The small size of the adductor muscle scars separates *Praenucula infirma* from other *Praenucula* species. In addition *P. infirma* is distinguished from *P. praetermissa* by its generally more elongate shape, and relatively shorter posterior hinge-plate with fewer teeth, and from *P. dispersa* by its larger, more strongly chevron-shaped teeth and more elongate shape. It bears some resemblance in shape to Hind's *Nuculana curta* (1910, p. 521, pl. 4, figs. 10-14, 14a, especially figs. 13, 14, 14a), but it lacks the central cartilage pit noted by Hind in that species. It differs in the same way from *Ctenodonta albertina* Ulrich and *C. filistriata* Ulrich (1894, pp. 598-599, pl. 42, figs. 76-82, text-fig. 44). It lacks the posterior lobe seen in *N. lobata* Hind (1910, p. 519, pl. 4, figs. 1-3). *P. infirma* shows no grouping of the growth lines as seen in *Deceptrix pulchra armoricana* Babin and Melou 1972 (= *D. cf. ciae* (Sharpe) of Babin and Robardet 1973) from the Caradoc of Normandy. Like *P. praetermissa*, *P. infirma* differs from *Praeleda ciae* (Sharpe) of Bradshaw (1970, pp. 633-636) and *C. ciae* (Sharpe) of Babin (1966, pp. 49-52, pl. 1, fig. 9) in the posterior teeth, the chevrons apparently pointing away from the umbo in the *C. ciae* specimens illustrated, but pointing towards it in *infirma*. This feature is, however, less marked than in *Praenucula praetermissa*. In this respect *P. infirma*, like *P. praetermissa*, resembles Sharpe's original *N. ciae* (1853, p. 149, pl. 9, figs. 5a-c).

Genus DECEPTRIX Fuchs, 1919

Type-species. By monotypy, *Deceptrix carinata* Fuchs 1919, p. 79, pl. 7, figs. 1, 2. See discussion under Praenuculidae above.

Deceptrix sp.

Plate 8, figs. 15, 18

v pars. 1843 *Arca regularis* Portlock, p. 427, pl. 34, fig. 2 [see *Deceptrix regularis*; IGS GSM 7805].

Material. Two left valves, IGS GU 1896 and UM K4202 and one right valve, IGS GSM 23215.

Horizon and locality. Bardahessiagh Formation; south of Craigbardahessiagh, Pomeroy, exact localities uncertain.

Description. Shell subquadrate, truncate posteriorly and slightly rounded to subtruncate anteriorly. The height to length ratio is between 0.62 and 0.68 and the umbo is at about the anterior two-fifths. Inflation of single valve 1.5 to 2.0 mm. The anterior and posterior hinge-plates meet at an angle of 140 to 150°. 4+ anterior and 10+ posterior teeth are visible in the specimens despite imperfect preservation. Anterior and posterior muscle scars indistinct, lying close below the ends of the hinge-plates. Sculpture of fine concentric lines of variable strength.

Discussion. Like other nuculoids, *Deceptrix* is uncommon in the Bardahessiagh Formation, and they can all be described under one heading. Lacking complete information on dentition and musculature, no specific name is proposed.

A specimen in the Sedgwick Museum (A16306; a left valve) is said to be from the Bardahessiagh Formation and may belong to the same species, but the anterior appears deformed and is very slender compared with the posterior.

A specimen collected by Fearnside, Elles and Smith, SM A16295, also from the Bardahessiagh Formation, was described by Reed (1952, p. 65) as *Ctenodonta cf. nitida* (Ulrich). It is a badly preserved left valve with 8+ posterior and 3+ anterior teeth, the dentition being obscured in part. Its height is 11 mm, and length 14 mm, giving height to length ratio 0.79. The umbo is at about the anterior third. The angle between the anterior and posterior hinge-plates is 115° and the inflation of the single valve is 2 mm. The musculature is unknown. It is unlike other *Deceptrix* from the Bardahessiagh Formation in having a more rounded outline and the umbo closer to the anterior. As Reed (1952, p. 65) observed, it bears a strong resemblance in form to *Ctenodonta nitida* (Ulrich 1894, p. 592, pl. 42, figs. 44-49), but he was clearly mistaken in suggesting that this specimen belongs to the same species as McCoy's *Arca quadrata* (see *Deceptrix apjohni*) and his comparison with *Nuculites dissimilis* (Portlock) is equally mistaken (see *N. cylindricus*).

Deceptrix apjohnni (Portlock 1843)

Plate 8, figs. 7, 8, 10, 11, 13, 14, 16, 17; text-fig. 4a

- v* 1843 *Pectunculus Apjohnni* Portlock, p. 429, pl. 34, fig. 8.
 v. 1843 *Pectunculus? ambiguus* Portlock, p. 430, pl. 34, fig. 11.
 v. 1846 *Pectunculus Apjohni* Portlock; McCoy, p. 19.
 v. 1846 *Arca quadrata* McCoy, p. 20, pl. 2, fig. 5 (reversed).
 . 1878 *Ctenodonta ambigua* Portlock; Baily, p. 28.
 v. 1952 *Ctenodonta apjohni* (Portlock); Reed, p. 60.

Type-specimens: IGS GSM 12409, Portlock's (1843, pl. 34, fig. 8) figured specimen, is here selected as lectotype of *Pectunculus apjohnni*; paralectotype UM K4219. The only known syntype of *P.? ambiguus* Portlock, IGS GSM 12410, is here selected as lectotype of *P. ambiguus*. The figured specimen of *Arca quadrata* McCoy NMI G.3. 1979, which is in the Griffith Collection, and which is the only known syntype, is here selected as lectotype of *A. quadrata*. All are from the Killey Bridge Formation, Pomeroy, exact locality uncertain, but possibly locality 3 of Mitchell, 1977.

Material: Sixteen specimens in IGS, BM, NMI, UM.

Horizon and locality. All from the Killey Bridge Formation (Ashgill, Cautleyan), with well-localized specimens recorded from the Crocknagargen Stream section (locality 1 of Mitchell 1977) and the Tirnaskea Stream section. Specimens from old collections are less well localized.

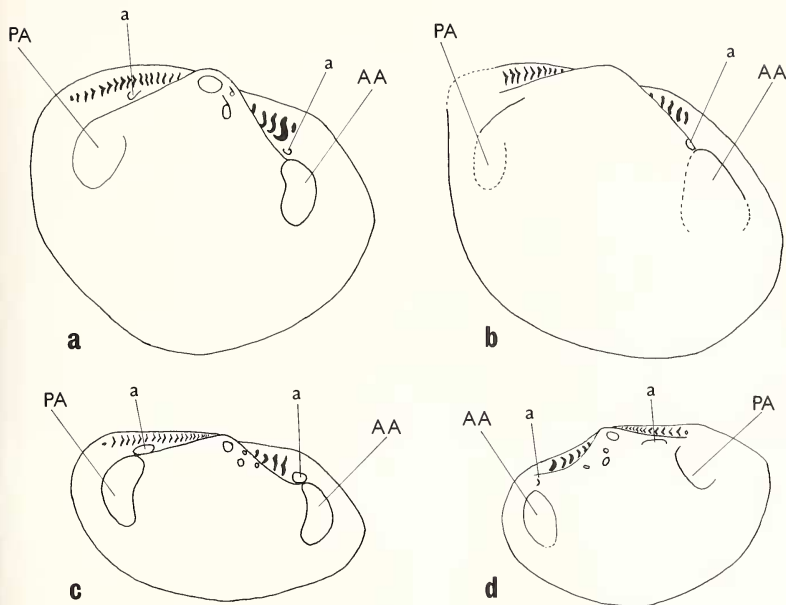
Measurements	L	H	H/L	AL/L	Angle
Max.	14.0 mm	14.0 mm	1.17	0.5	160°
Min.	4.8 mm	4.4 mm	0.81	0.32	125°
Mean	11.78 mm	10.23 mm	0.93	0.36	145°
Median	9.4 mm	9.2 mm	0.99	0.41	142.5°

Description. Rounded *Deceptrix*, occasionally subquadrate (as in *A. quadrata*), usually increasing in height towards the front. The postero-dorsal margin extends a little beyond the posterior hinge-line while the anterior hinge-plate occupies about half the length of the well-rounded antero-dorsal margin. The umbo is situated between the mid-point and the anterior third. Height occasionally greater than length but generally the height to length ratio is about 0.9–1.0. Maximum inflation of a single valve 4 mm seen in the lectotype, 14 mm long and 13 mm high. The posterior hinge-line is straight or gently curved, generally bearing up to 17 teeth (exceptionally 26 as in *A. quadrata*); the anterior hinge-plate is nearly straight or gently arched towards the body of the shell with 10+ teeth. The anterior and posterior hinge-plates meet below the umbo at an angle of 140–150°. The anterior adductor muscle scar is below the end of the anterior dental series, at about half the height of the shell and is one-quarter to one-third the height in diameter. The posterior adductor muscle scar is similar in size to the anterior scar and is close below the posterior dental series, a little anterior to its end. The scars of three umbonal accessory muscles are present (Pl. 8, fig. 17). Sculpture is of fine concentric lines, often of variable strength towards the margin. Pallial line not seen.

Discussion. Portlock (1843, p. 429) described his *Pectunculus apjohnni* as a 'very well marked species' and its well-rounded or subquadrate appearance is certainly distinctive in the Killey Bridge Formation fauna. It can only be confused, if fragmentary, with *Deceptrix semitruncata* but the two have distinctive forms, *D. apjohnni* more rounded and *D. semitruncata* more obliquely elongate and do not overlap in the range of their height-length ratios.

McCoy's *A. quadrata* is here regarded as synonymous with *D. apjohnni*. *A. quadrata* was described as 'rare' by McCoy (1846, p. 20) and only the type specimen is known and although it differs from Portlock's figured specimen of *D. apjohnni* in the manner outlined by McCoy, in particular its apparently square form (the result of the ventral margin being obscured by matrix), it is here considered to be an atypical specimen of *D. apjohnni*.

Reed (1952, pp. 60–61) likened *D. apjohnni* to several North American species which would now be regarded as *Similodonta*, and in this he was clearly misled by the general shape of the shell, for the dentition plainly shows *D. apjohnni* to be *Deceptrix*. In *Similodonta* the anterior and posterior teeth are equal in number and size. Of the described species of *Deceptrix*, none matches *D. apjohnni*.



TEXT-FIG. 4. *Deceptrix* spp. based on internal moulds, $\times 5$. (a) *D. apjohni* (Portlock), IGS NIL 8910, right valve. (b) *D. semitruncata* (Portlock), IGS GSM 12421, right valve. (c) *D. subtruncata* (Portlock), IGS NIL 8971, right valve. (d) *D. regularis* (Portlock), IGS NIL 8919, left valve. Abbreviations as in text-fig. 3. Note the differences in size and positions of the muscle scars and the differences in number and distribution of teeth. Pedal accessory muscle scars are shown but not labelled in (a), (c), and (d).

so closely in shape as the type species *D. carinata* Fuchs, 1919, which has fewer anterior and more posterior teeth.

Deceptrix semitruncata (Portlock 1843)

Plate 8, figs. 9, 12; text-fig. 4b

- v* 1843 *Pectunculus semi-truncatus* Portlock, p. 429 (*pars*), pl. 34, fig. 7.
- . 1878 *Ctenodonta semi-truncatus* Portl. (probably *transversa*); Bailly, p. 28.
- v? 1910 *Ctenodonta semitruncatus* Portlock; Hind, p. 525, pl. 3, figs. 23–25.
- v. 1952 *Ctenodonta semitruncata* (Portlock); Reed, p. 60, pl. 3, fig. 3.

Type-specimens. Lectotype selected by Reed 1952, p. 60, IGS GSM 12421, the specimen figured by Portlock; from the Killey Bridge Formation, Pomeroy, exact locality uncertain. K4203, a syntype of *Pectunculus semitruncatus* is now identified as *Praenucula* sp. from the Bardahessiagh Formation.

Material, horizon, and localities: Seven specimens in IGS and UM, all from the Killey Bridge Formation, recorded from the Crocknagargan Stream section (locality 1 of Mitchell 1977) and in the Portlock Collection, exact locality uncertain.

Measurements	L	H	H/L	AL/L	Angle
Max.	17.0 mm	13.0 mm	0.8	0.52	160°
Min.	11.0 mm	9.0 mm	0.65	0.36	140°
Mean	15.29 mm	11.14 mm	0.73	0.44	150°
Median	14.0 mm	11.0 mm	0.72	0.44	150°

Description. Obliquely ovate *Deceptrix*, increasing in height towards the anterior, in which the height to length ratio is between 0.6 and 0.8 and maximum inflation of a single valve seen is 3 mm. The umbo is situated between the midpoint and the anterior third. The posterior margin is truncate and the anterior margin is produced obliquely and is sometimes angular antero-ventrally where it is met by a slight umbonal ridge. The posterior hinge-plate is straight or very gently curved, bearing 17+ teeth. The anterior hinge plate is straight or slightly arched towards the body of the shell with 11+ teeth. The anterior and posterior dental series meet beneath the umbo. The anterior and posterior hinge-plates meet at an angle of about 150°. Musculature indistinct: anterior adductor muscle scar is at about half the height of the shell, below and a little before the end of the anterior dental series; posterior adductor muscle scar is below the hind third of the posterior dental series. Sculpture is of fine concentric lines of variable strength.

Discussion. *D. semitruncata* is compared with *D. apjohnni* under that species. *D. semitruncata* is similar in shape to *Ctenodonta britannica* Babin (1966, p. 54, pl. 1, figs. 1, 2), which may be referable to *Deceptrix* but which has more numerous anterior teeth on a hinge-plate apparently arched away from the body of the shell. *C. socialis* Ulrich (1894, p. 594, pl. 37, figs. 59, 60) is also similar in shape to *D. semitruncata* but is a very small species with relatively fewer anterior teeth (6 out of 19, as opposed to 11 out of 17 in *D. semitruncata*). No other described species of *Deceptrix* is readily comparable with *D. semitruncata*.

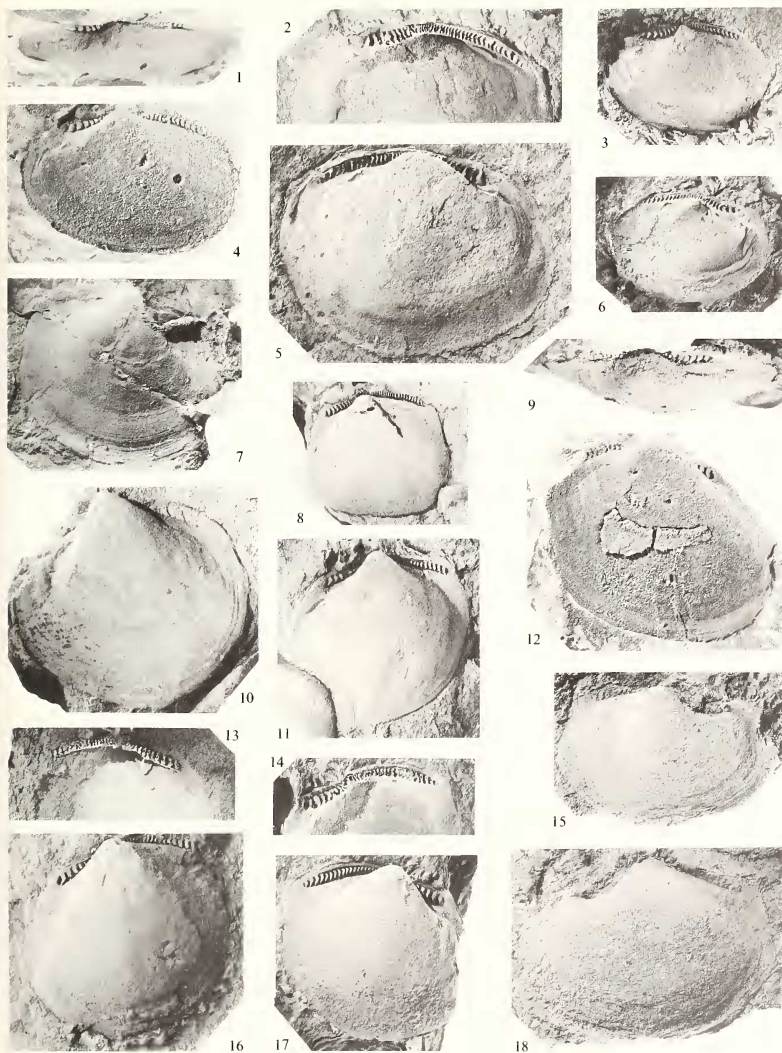
Deceptrix regularis (Portlock 1843)

Plate 8, figs. 1-6; text-fig. 4d

- v* pars 1843 *Arca regularis* Portlock, p. 427, pl. 34, fig. 2.
 . 1878 *Ctenodonta regularis* Portlock; Bailey, p. 28.
 v pars. 1910 *Ctenodonta regularis* Portlock; Hind, p. 524, ?pl. 3, figs. 15-17.
 v. 1952 *Ctenodonta regularis* (Portlock); Reed, p. 61, pl. 3, fig. 4.

EXPLANATION OF PLATE 8

- Figs. 1-6. *Deceptrix regularis* (Portlock 1843). 1, 4, oblique dorsal view and lateral view, internal mould of left valve, IGS GSM 12419, Pomeroy, exact locality uncertain. 2, 5, lateral view and latex cast, internal mould of right valve, IGS NIL 8803, Crocknagargan Stream section, Pomeroy (IGR c.H721737). 3, 6, lateral view and latex cast, internal mould of left valve, IGS NIL 8919, Crocknagargan Stream section, Pomeroy (IGR c.H721737). All Killey Bridge Formation (Ashgill, Cautleyan), $\times 3$.
- Figs. 7, 8, 10, 11, 13, 14, 16, 17. *Deceptrix apjohnni* (Portlock 1843). 7, latex cast of external mould of right valve, IGS GSM 12410, lectotype of *Pectunculus ambiguus* Portlock, 1843, Pomeroy, exact locality uncertain, $\times 3$. 8, internal mould of left valve, NMI G.3. 1979, lectotype of *Arca quadrata* McCoy, 1846, Pomeroy, exact locality uncertain, $\times 2$. 10, internal mould of left valve, lectotype, IGS GSM 12409, Pomeroy, exact locality uncertain, $\times 3$. 11, incomplete internal mould of left valve, UM K4253, Pomeroy, exact locality uncertain, $\times 3$. 13, 16, latex cast of hinge and lateral view, internal mould of left valve BM LL40005, locality 3 of Mitchell, 1977 (IGR H72977268), $\times 3$. 14, 17, latex cast of hinge and lateral view, internal mould of right valve, IGS NIL 8910, Crocknagargan Stream section, Pomeroy (IGR c.H721737), $\times 3$. All Killey Bridge Formation (Ashgill, Cautleyan).
- Figs. 9, 12. *Deceptrix semitruncata* (Portlock 1843), oblique dorsal view and lateral view, internal mould of right valve, lectotype, IGS GSM 12421, Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 3$.
- Figs. 15, 18. *Deceptrix* sp. 15, composite mould of right valve, IGS GSM 23215. 18, composite mould of left valve, UM K4202. Both Bardahessiagh Formation (Caradoc), south of Craigbardahessiagh, Pomeroy, $\times 3$.



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Type-specimens. Lectotype (as 'holotype') inadvertently designated by Hind (1910, p. 524), IGS GSM 7805, probably the specimen figured by Portlock (1843, pl. 34, fig. 2); remaining syntypes IGS GSM 12419, 23215, UM K4202. GSM 23215 and K4202 are now identified as coming from the Bardahessiahg Formation, exact locality uncertain, and are referred to *Deceptrix* sp. The lectotype and remaining syntype are from the Killey Bridge Formation, Pomeroy, exact locality uncertain but possibly locality 3 of Mitchell 1977.

Material, horizon, and localities. Two specimens from the Portlock Collection, IGS GSM 7805, 12419 and two from recent collections, IGS NIL 8803, 8919. All are from the Killey Bridge Formation; the locality of the Portlock specimens is uncertain but the remaining specimens are from the Crocknagargan Stream section (locality 1 of Mitchell 1977).

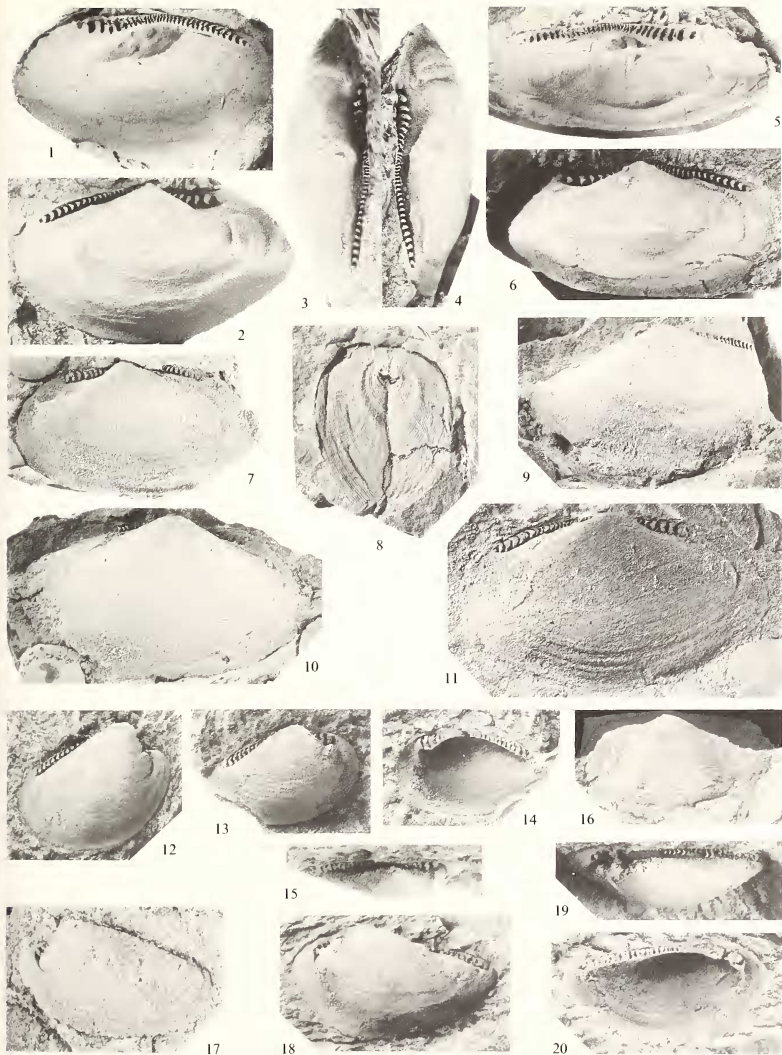
Measurements	L	H	H/L	AL/L	Angle
Max.	17.5 mm	13.0 mm	0.75	0.46	150°
Min.	10.5 mm	7.0 mm	0.64	0.36	145°
Mean	9.5 mm	13.5 mm	0.70	0.42	148.75°
Median	14.0 mm	10.0 mm	0.70	0.41	147.5°

Description. Transversely ovate *Deceptrix*, rounded at both anterior and posterior ends increasing in height slightly towards the rear. Height to length ratio about 0.7. The umbo is at about the anterior two-fifths. The maximum inflation of a single valve is 3 mm. The anterior and posterior hinge-plates meet below the umbo at an angle of 150° with a continuous series of nearly twice as many smaller posterior teeth than anterior teeth, up to 15 anterior and 25 posterior in a large specimen (Pl. 8, figs. 2, 5). The posterior hinge-plate is gently curved, the anterior is slightly arched towards the body of the shell. Adductor muscle scars vary from quite strongly impressed (Pl. 8, figs. 3, 6) to indistinct. Anterior scar lies below and a little in front of the end of the anterior teeth; the posterior scar lies a little anterior to the end of the posterior teeth. Three umbonal accessory muscle scars are present (Pl. 8, figs. 3, 6). Sculpture is not well seen in the specimens but appears to be of fine concentric lines.

Discussion. The lectotype of *Deceptrix regularis*, IGS GSM 7805, shows little other than the shape and is not illustrated here. It is perhaps surprising that Hind (1910, p. 524) regarded this as the type since GSM 12419 shows dentition, and there is no clear evidence which was the specimen figured by Portlock [see Tunnicliff 1980].

EXPLANATION OF PLATE 9

- Figs. 1-7, 9-11. *Deceptrix subtruncata* (Portlock 1843). 1-6, IGS NIL 8971, slab with internal moulds of both valves, Crocknagargan Stream section, Pomeroy, (IGR c.H721737): 1, 2, latex cast and lateral view of right valve; 5, 6, latex cast and lateral view of left valve (in fig. 6, difficulty in lighting the subject has resulted in a shortened appearance of the anterior); 3, 4, dorsal views of left and right valves juxtaposed. 7, internal mould left valve, IGS GSM 12413, holotype of *Ctenodonta desertia* Reed 1952, Pomeroy, exact locality uncertain. 9, oblique dorsal view and lateral view, damaged internal mould of left valve, IGS GSM 12423, lectotype of *Arca transversa* Portlock 1843, Pomeroy, exact locality uncertain. 10, internal mould right valve, IGS GSM 12422, Pomeroy, exact locality uncertain. 11, internal mould right valve, lectotype, IGS GSM 12424, Pomeroy, exact locality uncertain. All Killey Bridge Formation (Ashgill, Cautleyan), $\times 3$.
- Fig. 8. *Hippocardia praeprestis* (Reed 1952), holotype, IGS GSM 24147, Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 3$.
- Figs. 12-20. *Concavodonta imbricata* (Portlock, 1843). 12, internal mould of right valve, IGS Zs 2790. 13-15, composite mould of right valve, IGS GU 1583; 15, dorsal view; 14, latex cast; 13, lateral view. 16, ?external cast of left valve, NMI G.1. 1979, lectotype of *Nucula subacuta* McCoy, 1846. 17, ?composite mould of left valve, NMI G.2. 1979, cited by McCoy 1846 as *Nucula protei* Münster. 18-20, composite mould of left valve, BM LL40003; 18, lateral view; 19, dorsal view; 20, latex cast. All Killey Bridge Formation (Ashgill, Cautleyan), figs. 12-15, 18-20, from locality 3 of Mitchell 1977 (IGR H7297 7268), figs. 16, 17, Pomeroy, exact locality uncertain. All $\times 4$.



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Although in position of umbo and in height-length ratio *D. regularis* closely matches the range of *D. semitruncata*, it can be readily distinguished from that species by its transverse rather than oblique elongation and its increase in height towards the posterior end, while *D. semitruncata* is highest towards the anterior end. It is less easy to distinguish between *D. regularis* and *D. subtruncata*, but the latter is always more transverse with the highest part of the shell at the umbo rather than towards the posterior end, and has relatively larger adductor muscle scars and fewer teeth.

Pojeta's illustrations of his *Deceptrix* (*D.*) n. sp. 1 (1978, pl. 1 figs. 1, 2) show a close similarity to *D. regularis* except that the umbo is closer to the mid-point and the shell is highest a little anterior of the umbo and thus more closely resembles *D. subtruncata*. No other species of *Deceptrix* is closely comparable with *D. regularis*.

Deceptrix subtruncata (Portlock 1843)

Plate 9, figs. 1-7, 9-11; text-fig. 4c

- v* 1843 *Arca sub-truncata* Portlock, p. 427, pl. 34, fig. 1.
- v pars. 1843 *Arca transversa* Portlock, p. 428, pl. 34, fig. 4 [*non* IGS GSM 12425 *Nuculites* sp.]
- v. 1843 *Arca Eastnori?* (Murchison); Portlock, p. 427, pl. 34, fig. 3.
- v. 1846 *Arca subtruncata* Portlock; McCoy, p. 20.
- v. 1846 *Arca transversa* Portlock; McCoy, p. 20.
- . 1878 *Ctenodonta transversa* Portl.; Baily, p. 28.
- v non. 1910 *Ctenodonta* aff. *transversa* Portlock; Hind, p. 523, pl. 3, figs. 12-14.
- 1910 *Ctenodonta eastnori* Portlock; Hind, p. 525, pl. 3, fig. 20, ?figs. 21, 22.
- ? 1946 *Ctenodonta transversa* (Portlock); Reed, p. 202.
- v. 1952 *Ctenodonta subtruncata* (Portlock); Reed, p. 62, pl. 3, fig. 6.
- v. 1952 *Ctenodonta transversa* (Portlock); Reed, p. 63.
- v. 1952 *Ctenodonta deserta* Reed, p. 64, pl. 3, fig. 8.

Type-specimens. IGS GSM 12424, the specimen figured by Portlock (1843, pl. 34, fig. 1) is here selected as lectotype of *Arca subtruncata*; paralectotypes IGS GSM 12422, TCD 14763. IGS GSM 12423, the specimen figured by Portlock (1843, pl. 34, fig. 4) was selected as lectotype of *A. transversa* by Reed 1952, p. 68; remaining syntypes IGS GSM 12425, TCD 7854. The holotype of *Ctenodonta deserta* Reed is IGS GSM 12413 by original designation (1952, p. 64). All from the Killey Bridge Formation, Pomeroy, exact localities uncertain but possibly locality 3 of Mitchell 1977.

Material, horizon, and localities. Many specimens in IGS, UM, SM, TCD, in both old and recent collections, are all from the Killey Bridge Formation. Recent collections contain specimens recorded from localities 1 and 3 of Mitchell 1977, while old collection material is less well localized.

Measurements	L	H	H/L	AL/L	Angle
Max.	19.4 mm	11.4 mm	0.64	0.51	170°
Min.	10.0 mm	5.4 mm	0.54	0.37	140°
Mean	17.3 mm	10.15 mm	0.59	0.48	153.8°
Median	16.76 mm	10.26 mm	0.59	0.44	153.6°

Description. Transversely elongate, subelliptical *Deceptrix*, with obliquely subtruncate anterior and rounded posterior end. Maximum height of shell below umbo. Height to length ratio about 0.6. Umbo nearly central. Maximum inflation of a single valve is 5.0 mm in a valve 17.5 mm long and 10.0 mm high. Hinge-line straight or slightly curved; anterior and posterior hinge-plates meet at an angle of about 155-160° in most specimens. The posterior dental series is straight with up to twenty teeth seen in both right and left valves. The anterior dental series is slightly arched towards the body of the shell with up to twelve teeth in the right valve and thirteen in the left (a single, tiny subumbonal tooth in the left valve is here counted as anterior). The dental series meet below the umbo. Adductor muscle scars are large, nearly half the height of the shell in diameter, and distinct, each lying slightly in front of, and below the end of, its corresponding dental series. Four umbonal accessory muscle scars are present in each valve (Pl. 9, figs. 1-6), three distinct, one less so. Sculpture of fine concentric lines of variable strength especially towards the margin. Pallial line not seen.

Discussion. There is no basis on which *A. transversa* Portlock (IGS GSM 12423) or the specimen which he labelled and described as *A. Eastnori* can be separated from *Deceptrix subtruncata* (Portlock). Despite Reed's observations (1952, p. 63) to the contrary, and Portlock's original description (1843, p. 428), the proportions of the shell in *A. transversa* are not greatly different from those of *D. subtruncata* although the type specimen of *A. transversa* is incomplete and its length must be estimated. Portlock's figures of the three species (1843, pl. 34, figs. 1, 3, 4) are poor and measurements taken from them are unreliable.

Reed (1952, p. 64) quite reasonably dissociated Portlock's specimen of *A. eastnori* (GSM 12413) from Sowerby's species, but he failed to recognize its affinities with *D. subtruncata* and created a new species, *C. deserta*. The second Portlock specimen of *A. eastnori* (GSM 12414) which Reed compared to *C. cingulata* Ulrich is *Nuculites* sp.

The differences between *D. subtruncata* and *D. regularis*, with which it might be confused, are discussed under the latter species. Of the published species of *Deceptrix* none compares so closely with *D. subtruncata* as that figured by Pojeta (1978, pl. 1 figs. 1, 2) as *D. (D.)* n. sp. 1 which has similar numbers of teeth, position of umbo, and, in the case of Pojeta's figure 2, a closely similar height to length ratio to the maximum seen in *D. subtruncata*.

Genus SIMILODONTA Soot-Ryen, 1964

Type-species. Designated by Soot-Ryen 1964, p. 498, *Tellinomya similis* Ulrich, 1892.

Similodonta? sp.

Plate 7, fig. 25

Material. Left valve, UM K4205 and a slab, UM K4241, bearing a left and a right valve; all composite moulds.

Horizon and locality. Bardahehsiagh Formation, locality uncertain but south of Craigbardahehsiagh, Pomeroy.

Measurements	H	L	H/L	AL/L	Angle
K4241 (both valves)	15.0 mm	16.0 mm	0.94	0.5	c. 110°
K4205	15.6 mm	14.0 mm	1.11	0.5	95–100°

Description. Triangular, equivalve, about as high as long with the umbo at the centre. Anterior and posterior hinge-plates meeting at about 100°. Details of hinge unknown. Anterior adductor muscle scar distinct, lying below anterior end of the anterior hinge-plate which is arched towards the body of the shell. Posterior adductor muscle scar not known. Auxiliary musculature unknown. Sculpture of fine concentric striae (about 7 per mm) with coarser striae developing at later growth stages.

Discussion. Reed's description (1952, p. 63) of *Ctenodonta perangulata* suggests that *C. perangulata* should be placed in *Similodonta*, but examination of his holotype (SM A16454) has shown it to be a *Nuculites* and it is here considered to be synonymous with *Nuculites cylindricus* (Portlock).

Genus CONCAVODONTA Babin and Melou, 1972

Type-species. Originally designated by Babin and Melou 1972, p. 83, *Nucula ponderata* Barrande, 1881, from the Vinice, Zahofany, and Bohdalec Formations (Caradoc) of Bohemia (Havlíček and Vaněk 1966), recorded again from Bohemia by Pfab 1934, and also recorded from the Upper Ordovician of Normandy (Babin and Robardet 1973), and, with doubt, the Caradoc of Brittany (Babin and Melou 1972).

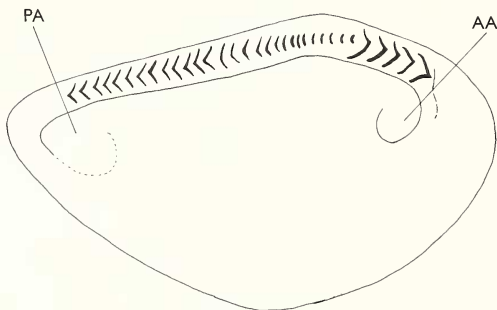
Diagnosis after Babin and Melou (1972, p. 83). Genus of Praenuculidae of fairly rounded shape, the posterior extremity being a little more slender than the anterior. Umbo prosogyrate. Imprints of adductor muscles subequal, the anterior more strongly impressed in the shell at its posterior edge. Pallial line complete. Teeth concavodont, that is, characterized by teeth in chevron with the concavities towards the umbo. Ornamentation fairly strong and regular, concentric.

Concavodonta imbricata (Portlock 1843)

Plate 9, figs. 12–20; text-fig. 5

- * 1843 *Nucula acuta?* (Sowerby) var. *imbricata* Portlock, p. 430, pl. 34, fig. 10.
 v. 1846 *Nucula protei* Münster; McCoy, p. 19.
 v. 1846 *Nucula subacuta* McCoy, p. 19, pl. 2, fig. 3 (reversed).
 v non. 1910 *Nuculana imbricata* Portlock; Hind, p. 519, pl. 4, figs. 4–7, 7a [none of these specimens is referable to *Concavodonta* but are referable to ?*Praenucula*. Name *imbricata* re-established].
 v. 1952 *Nuculana?* *imbricata* (Portlock); Reed, p. 66 [affirms the use of *imbricata*].
 v. 1952 *Ctenodonta* cf. *gibberula* (Salter); Reed, p. 65.

Type specimens. Portlock's type specimen remains untraced (Tunnicliff 1980). A lectotype for *Nucula subacuta* McCoy, 1846, is here designated NMI G.I. 1979, the only known syntype.



TEXT-FIG. 5. *Concavodonta imbricata* (Portlock), dentition and musculature based on composite mould, left valve, BM LL40003, c. $\times 10$. Compare with Pl. 9, fig. 20. Abbreviations as in text-fig. 3.

Material. Thirty-six specimens in IGS, UM, BM, SM, mostly internal moulds of single valves, some with counterparts, many apparently composite moulds showing the concentric ornament on the internal mould.

Horizon and localities. All specimens are from the Killey Bridge Formation, of Pomeroy, Co. Tyrone. Most specimens are from locality 3 of Mitchell 1977. Others are from localities 1 and 2 of Mitchell and from the Tirnaskea Stream section. Specimens from old collections are less precisely localized.

Measurements	L	H	H/L	AL/L	Angle
Max.	9.4 mm	6.6 mm	0.923	0.455	155°
Min.	3.8 mm	2.4 mm	0.517	0.250	100°
Mean	6.6 mm	4.5 mm	0.685	0.3367	131.1°
Median	6.6 mm	4.5 mm	0.720	0.3525	127.5°

Description. Ovate, equivalve nuculoid. Height generally about 0.7 of the length but variable. Prosogyrate umbo at about the anterior third and extending a little above the hinge-line. Convexity greatest below umbo, maximum inflation of a single valve 1.6 mm seen in a valve 9.4 mm long and 5.0 mm high. Angle between anterior and posterior hinge-plates about 130°. Posterior hinge-plate straight. Teeth concavodont (see generic diagnosis), anterior larger than posterior, apparently passing beneath umbo in a continuous series. 6+ anterior teeth in both valves, 19+ posterior teeth seen in right valve and 16+ in left valve (29 posterior teeth were seen in one large left valve (Pl. 9, fig. 20)). Anterior and posterior adductor muscle scars clearly distinguished; anterior slightly larger and more deeply impressed than posterior and most deeply impressed on its posterior

edge. Accessory muscles unknown. Pallial line probably represented by a change in convexity close to the ventral margin. Ligament and shell material unknown. Two forms of concentric sculpture observed; coarse (3 to 6 striae per mm) giving the imbricate appearance (Pl. 9, fig. 13), and fine (12 to 20 striae per mm) (Pl. 9, fig. 12).

Discussion. This is the first record of *Concavodonta* from the British Isles but material under study from Caradoc and Ashgill rocks in north Wales includes examples of *Concavodonta* sp. Specimens not showing the dentition may be distinguished from *Deceptrix* and *Praenucula* by the relatively coarse concentric sculpture, the position of the umbo and especially the straight posterior hinge-line. Ulrich's figures (1894, p. 589, pl. 38, figs. 25-28; pl. 42, figs. 38-40) of *Ctenodonta planodorsata* (Ulrich), from the Trenton Shale, show similar straight sets of concavodont teeth, but the angle between the anterior and posterior hinge-plates is more acute (105°) and the position of the posterior adductor muscle scar differs, being in line with the posterior hinge-plate in *C. planodorsata* but lying internally (i.e. antero-ventrally) to the teeth in *Concavodonta imbricata*. *C. ponderata*, as described and figured by Babin and Melou (1972), Babin and Robardet (1973), and by Pfab (1934), differs from *C. imbricata* only in that the posterior hinge-plate appears gently curved.

Superfamily NUCULANACEA H. Adams and A. Adams, 1858

Family MALLETHIDAE H. Adams and A. Adams, 1858

Genus NUCULITES Conrad, 1841

Type-species. Designated by Miller 1889, p. 496, *Nuculites oblongatus* Conrad, 1841, from the probable Middle Devonian (McAlester 1968, p. 37) of New York.

Nuculites cylindricus (Portlock 1843)

Plate 10, figs. 1-17

- ? 1841 *Nuculites planulatus* Conrad, p. 50 [see Bretsky and Bretsky 1977, for synonymy].
- v* 1843 *Arca cylindrica* Portlock, pp. 428, 759, pl. 34, fig. 9.
- v. 1843 *Arca dissimilis* Portlock, pp. 428, 759, pl. 34, fig. 5.
- v. 1843 *Arca obliqua* Portlock, pp. 429, 759, pl. 34, fig. 6.
- v pars. 1843 *Arca Eastnori* (Murchison); Portlock, pp. 427, 759, non pl. 34, fig. 3.
- v. 1846 *Arca cylindrica* Portlock; McCoy, p. 19.
- v. 1846 *Arca dissimilis* Portlock; McCoy, p. 20.
- v. 1846 *Arca obliqua* Portlock; McCoy, p. 20.
- 1875 *Ctenodonta obliqua* Portlock; Baily, p. 35, pl. 12, fig. 2.
- 1878 *Ctenodonta dissimilis* Portlock; Baily, p. 28.
- 1878 *Ctenodonta obliqua* Portlock; Baily, p. 28.
- v non. 1910 *Ctenodonta dissimilis* Portlock; Hind, p. 522, pl. 3, figs. 5-7.
- v non. 1910 *Ctenodonta eastnori* Portlock; Hind, p. 525, pl. 3, figs. 20-22.
- v non. 1910 *Ctenodonta obliqua* Portlock; Hind, p. 524, pl. 3, figs. 18, 19.
- ? 1946 *Clidophorus diu* Lamont, p. 365, pl. 1, fig. 3.
- v. 1952 *Clidophorus cylindricus* (Portlock); Reed, p. 66, pl. 3, fig. 9.
- v. 1952 *Ctenodonta dissimilis* (Portlock); Reed, p. 63.
- v. 1952 *Ctenodonta obliqua* (Portlock); Reed, p. 61, pl. 3, fig. 5.
- v. 1952 *Clidophorus occultus* Reed, p. 67, pl. 3, fig. 10.
- v. 1952 *Ctenodonta perangulata* Reed, p. 63, pl. 3, fig. 7.
- v pars. 1952 *Ctenodonta deserta* Reed, p. 65, non pl. 3, fig. 8 [IGS GSM 12414, non holotype IGS GSM 12413].

Type-specimens. Lectotype of *Nuculites cylindricus* (Portlock) here selected, IGS GSM 12416, the specimen figured and labelled by Portlock and described by Reed (1952, p. 66); paralectotypes are TCD 7876, 14761-14762, UM K4220, 4267. Lectotype of *Arca dissimilis* Portlock, selected Reed (1952, p. 63), IGS GSM 12411; paralectotype is IGS GSM 12412. For *A. obliqua* Portlock, Hind, (1910, p. 524) selected IGS GSM 12415 as lectotype, leaving paralectotypes IGS GSM 12417, 12418. The holotype of *Clidophorus occultus*

Reed is IGS GSM 12415 by original designation (*occultus* becomes a junior objective synonym of *obliqua*). The holotype of *Ctenodonta perangulata* Reed is SM A16454 by original designation. The holotype of *Clidophorus diu* Lamont is Lamont Collection No. 1.

Material, localities, and horizon. Many specimens in IGS, TCD, UM, NMI, BM(NH), and SM, both in old and new collections. All are from the Killey Bridge Formation of Pomeroy. Apart from recently collected material especially from localities 1 and 3 of Mitchell (1977), specimens are generally poorly localized.

Measurements	L	H	H/L	AL/L
Max.	21.0 mm	16.0 mm	0.94	0.46
Min.	8.4 mm	3.8 mm	0.43	0.15
Mean	15.23 mm	9.1 mm	0.61	0.33
Median	14.7 mm	9.9 mm	0.68	0.30

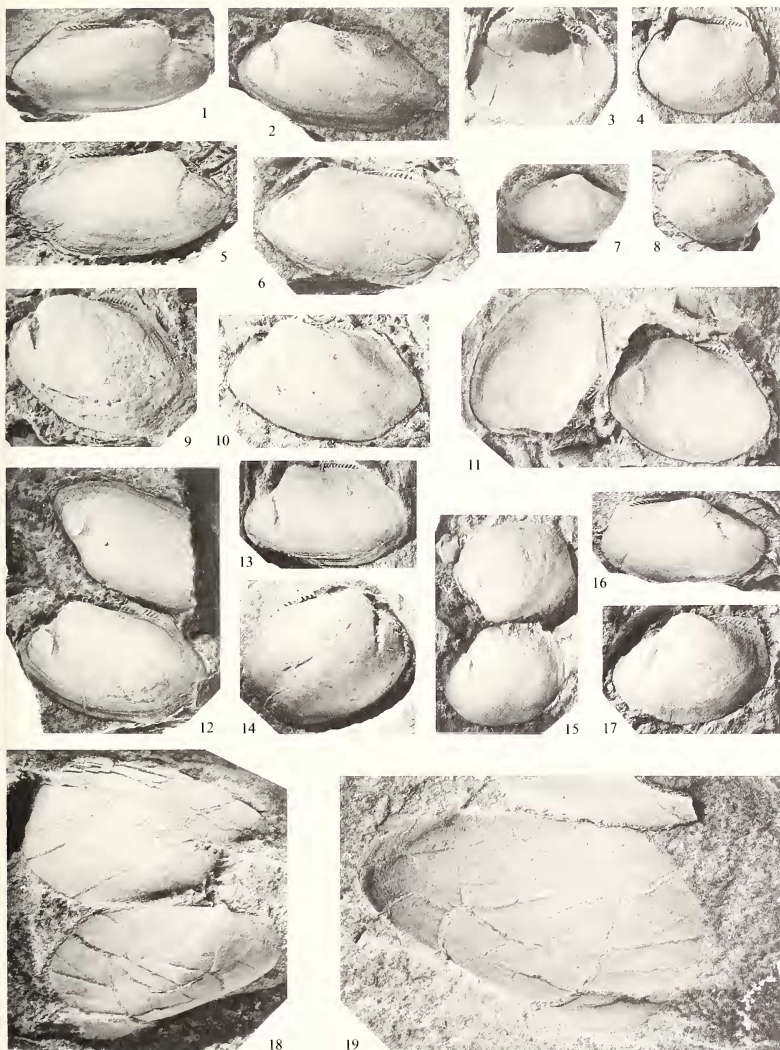
Description. *Nuculites* of very variable shape, from posteriorly elongate transversely or obliquely, or rounded, to more or less truncate posteriorly. Umbo between the mid-point and the anterior one-fifth. The height to length ratio varies between about 0.4 and 0.95. Many specimens show a posterior fold running from the umbo towards the postero-ventral margin (Pl. 10, fig. 5). Occasionally a weak anterior fold is developed running from the umbo towards the antero-ventral margin (Pl. 10, fig. 12), anterior to the position of the septum. Septal position indicated clearly by a strong impression on internal moulds and often evident on external moulds. The septum extends, usually vertically, from the hinge-line to half-way to the margin (e.g. Pl. 10, figs. 2, 9) but may appear to be directed slightly posteriorly (e.g. Pl. 10, figs. 1, 5) or more markedly towards the anterior end (e.g. Pl. 10, fig. 17). Posterior hinge-plate straight or slightly curved near the hind end (Pl. 10, fig. 9); anterior hinge-plate generally at an angle of about 150° to the posterior hinge-plate, but the angle is variable between 120 and 180°. Dentition taxodont: 3+ anterior teeth and 15+ posterior teeth. The anterior teeth are simple or slightly sigmoidal and are larger than the posterior teeth which are chevron-shaped pointing towards the umbo and becoming simpler towards the posterior end. Dentition below umbo obscured in all specimens. Maximum inflation of a single valve seen 3.5 mm in a valve 15.4 mm long. Anterior adductor muscle scar distinct and occupying much of the portion of the shell anterior to the septum: posterior adductor and other muscle scars unknown. Sculpture of fine (c. 16–20 per mm) concentric lines with some coarser lines interspersed, especially towards the margin in larger specimens.

Discussion. Bretsky and Bretsky (1977) have shown that *N. planulatus* Conrad, 1841, from the Upper Ordovician of Quebec is a highly variable species; Watkins (1978, p. 44) has done the same with the Silurian species *N. antiquus* (J. de C. Sowerby). This also appears to be the case with the Killey Bridge Formation species. As isolated specimens, the types of Portlock's *Arca cylindrica*, *A. dissimilis*, and *A. obliqua* appear to be different species but, seen in combination with the many other specimens of *Nuculites* both in old and recent collections, they appear to be extreme variants

EXPLANATION OF PLATE 10

Figs. 1–17. *Nuculites cylindricus* (Portlock 1843). All preserved as internal moulds. All Killey Bridge Formation (Ashgill, Cautleyan). 1, right valve, lectotype, IGS GSM 12416. 2, left valve, UM K4266. 3, 4, latex cast and lateral view, left valve, UM 1920–834. 5, right valve UM K4267. 6, left valve, UM K4226. 8, right valve, IGS GSM 12412. 9, left valve, IGS GSM 12418. 10, left valve, UM K4263. 11, left and right valves, probably of the same individual, UM K4264, lit from bottom right to accommodate both valves. 12, nearly conjoined valves, UM K4233. 14, right valve, IGS GSM 12415, lectotype of *Arca obliqua* Portlock 1843. 15, conjoined valves, IGS GSM 12411, lectotype of *Arca dissimilis* (Portlock 1843). 16, right valve, UM K4255. 17, left valve, UM K4231. All Pomeroy, exact locality uncertain, $\times 2\frac{1}{2}$. 7, right valve, IGS GU 2087, 13, left valve, IGS GU 2061. Both locality 3 of Mitchell 1977 (IGR H7297 7268), $\times 2\frac{1}{2}$.

Figs. 18, 19. *Nuculoid* gen. et sp. nov., IGS NIL 9240–1. 18, both valves, showing the fracturing of both and the greater displacement of parts of the left valve, $\times 2$. 19, concave latex cast of composite mould, right valve showing the fine dentition, concentric ornament, and shallow sulcus, $\times 3$. Tirnaskea Formation (Ashgill, Hirnantian), Crocknagargan Stream section, Pomeroy (IGR H7272737).



TUNNICLIFF, Ordovician bivalves

of one form. There is no clear relationship between growth and height-length ratio that can be related to Portlock's species, and although many specimens may, by eye, be placed in one or other of Portlock's nominal species, there are others which fall between any two of the Portlock forms. I am unable to quantify any differences between these 'species' and choose therefore to place them in synonymy. There may be an argument for retaining Portlock's *obliqua* and *dissimilis* as terms for morphs.

Reed's (1952) *Clidophorus occultus* is a junior objective synonym of Portlock's *A. obliqua* and his *Ctenodonta perangulata* falls within the range of the *A. dissimilis* form. *Clidophorus diu* Lamont (1946), from the Lower Drummuck Group of Girvan, Ayrshire, appears from the figure and from Lamont's observations to fall within the range of the *A. cylindricus* form, differing only in the absence of the posterior fold commonly seen in specimens of that form.

Unfortunately, while Bretsky and Bretsky could relate the relative abundances of the different forms of *N. planulatus* to a known stratigraphic sequence, no such sequence is available in the Killey Bridge Formation, and each collection and locality is, in effect, isolated. Many specimens have only vague locality information.

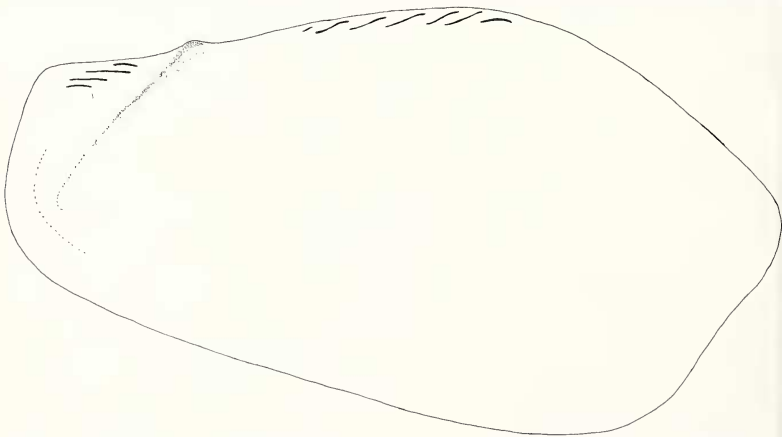
On the basis of the description, figures, and measurements given by Bretsky and Bretsky it is not clear that *N. cylindricus* is distinct from *N. planulatus*, but Portlock's name is retained pending some closer comparison.

NUCULOID gen. and sp. nov.

Plate 10, figs. 18, 19; text-fig. 6

Material, horizon, and locality. A single specimen IGS NIL 9240-9241, showing nearly conjoined valves, crushed but apparently not distorted, preserved as a composite mould. From the Tirnaskea Formation (Ashgill, Hirnantian) of the Crocknagargan Stream section, Pomeroy, Co. Tyrone (IGR H722 737).

Description. Shell obliquely ovate and modioliform in appearance. For right valve, height 13.3 mm, length 22.9 mm giving a height-length ratio of 0.58. Inflation of the single valve at least 1.4 mm. The small, prosogyrate umbo is at the anterior three-tenths. A slight umbonal ridge runs to the postero-ventral angle at an angle of



TEXT-FIG. 6. Nuculoid gen. and sp. nov., based on latex cast of composite mould of right valve, IGS NIL 9240, $\times 6.5$. Compare with Pl. 10, fig. 19.

55° to the hinge-line, giving the shell its oblique appearance. A little posterior to the umbonal ridge is a shallow sulcus, reflected in the sculpture and sinus in the posterior margin. This sulcus is at an angle of 35° to the hinge-line. The posterior margin is otherwise rounded ventrally and obliquely slanted towards the hinge-line. The anterior margin is also obliquely slanted. The ventral margin is straight. The hinge-line is straight on both sides of the umbo, curving slightly at the posterior end. The anterior hinge-plate bears 3-4 thin blade-like parallel teeth, becoming shorter towards the anterior. The posterior hinge-plate bears 9+ similarly thin blade-like parallel teeth extending to the postero-dorsal angle. Musculature, ligament, pallial line unknown. Sculpture of fine regular concentric lines (about 7 per mm) more pronounced on the posterior slope of the shell.

Discussion. Bivalves are uncommon in the Tirnaskea Formation and are usually poorly preserved. It is unfortunate that this specimen, one of the best preserved from that horizon, should prove enigmatic. In outline it might be taken for *Modiolopsis* sp., but the presence of numerous taxodont teeth both before and behind the umbo precludes assignment to the Modiomorphidae. Suspicion that the teeth are the result of slight deformation can be dismissed since the anterior and posterior teeth are aligned contrariwise. This is endorsed by the way in which the posterior teeth of both valves can be seen in the specimen. Had these structures been produced by some post-depositional deformation, one would have expected them all to be parallel. It is possible but unlikely, that the structures are related to the ligament.

Although generally smaller in size than the Pomeroy specimen, *Silicula* Jeffreys, as described and illustrated by Allen and Sanders 1973, (pp. 263-309) and Allen 1978 (p. 394) shows many similar features: small umbones, ovate, flattened form, fine, elongate teeth. *Silicula* is a modern deep-sea protobranch of the family Siliculidae grouped by Allen (1978, p. 392) with the Malletiidae and others in the Nuculanoida. The strong resemblance in form to *Silicula* suggests that the Pomeroy specimen was a deep-water form, as would seem likely since the Tirnaskea Formation passes into the overlying graptolitic, presumably offshore, Llandovery strata (Mitchell 1977, p. 5).

Subclass PTERIOMORPHIA Beurlen, 1944

Order ARCOIDA Stoliczka, 1871

Superfamily CYRTODONTACEA Ulrich, 1894

Family CYRTODONTIDAE Ulrich, 1894

Genus CYRTODONTA Billings, 1858

Type species. *Cyrtodonta rugosa* Billings, 1858, by subsequent designation of Williams and Breger 1916, p. 149.

Cyrtodonta? expansa (Portlock 1843)

Plate 11, figs. 1, 3, 4, 9

v* pars. 1843 *Modiola expansa* Portlock, p. 425, pl. 33, fig. 6 [pars: longer variety].

v* pars. 1843 *Modiola Brycei* Portlock, p. 425, pl. 33, fig. 7 [pars: see *Cyrtodonta? securiformis* (Portlock)].

v(?) 1843 *Modiola expansa* Portlock; McCoy, p. 18.

v(?) 1875 *Modiolopsis expansa* Portlock; Bailly, p. 35, pl. 12, fig. 2.

1878 *Modiolopsis expansa* Portlock; Bailly, 1878 [includes *Brycei* in *expansa* with doubt].

v. 1952 *Modiodesma expansum* (Portlock); Reed, p. 71, pl. 3, fig. 16.

v. 1952 *Goniophora brycei* (Portlock); Reed, p. 78 [pars: see *Cyrtodonta? securiformis* (Portlock)].

Type-specimens. Lectotype here selected, IGS GSM 12445, the type of Portlock's long variety of *M. expansa* (1843, p. 425). For Portlock's small variety see *Cyrtodonta? securiformis* (Portlock). Lectotype of *Modiola brycei* Portlock here selected IGS GSM 12443, Portlock's figured specimen: other syntypes (paralectotypes) IGS GSM 12444, GSM 22038 (not certainly a syntype), UM K4206-4210, 4249. All from the Bardahessiagh Formation, Pomeroy, Co. Tyrone, exact localities uncertain, south of Craigbardahessiagh.

Material, localities, and horizon. A few specimens in IGS (GSM 12443-5) and UM (K4244, 4247, ?4248, ?4249) all from the Portlock Collection. Two specimens in the Griffith Collection at NMI may belong to this species. All composite moulds from the Bardahessiagh Formation, locality as above.

Measurements of type-specimen. IGS GSM 12445: H 29.6 mm, L 50.6 mm, AL 8.6 mm.

Description. Elongate, obliquely ovate, becoming higher towards the posterior end, with a height-length ratio between about 0.6 and 0.7. The straight hinge-line is about half as long as the total length of the shell. Antero-dorsal margin almost straight or gently curved and meeting the hinge-line at an angle of about 150°. Ventral margin almost straight. Umbones prosogyrate and placed at about 0.15 of the length from the front, projecting a little above the hinge-line. A rounded umbonal ridge extends backwards at about 35° from the hinge-line to the ventral margin at the point furthest from the umbo. Preservation poor, but two posterior lateral teeth can be seen at the posterior end of the hinge-line in the right valve and one in the left. anterior teeth are not known. The anterior adductor muscle scar is small, the posterior is unknown. Maximum inflation seen in a single undistorted valve is 4.1 mm in a valve 45 mm long. Sculpture of irregular concentric striae.

Discussion. *C.?* *expansa* and *C.?* *securiformis* (Portlock) show the effects of distortion more than other species from the Bardahessiagh Formation and this has influenced their nomenclatorial history. Portlock (1843, p. 425) noted two varieties of *M. expansa*; a longer variety, which he figured (1843, pl. 33, fig. 6), and a smaller variety which he described briefly. The smaller variety is now placed in *C.?* *securiformis*. Portlock's *M. brycei* (1843, p. 425, pl. 33, fig. 7) was based on specimens which he described as 'somewhat distorted by pressure' (1843, p. 426). Reed (1952) removed the specimens of Portlock's smaller variety from *M. expansa* and placed them in two new species, *Orthodesma tyronense* (1952, p. 71) and *Whiteavesia subexpansa* (1952, p. 72). These are now placed in *C.?* *securiformis*. Examination of Portlock's type material, some of which was not available to Reed, shows that those specimens which both Portlock and Reed placed in *brycei* are either *expansa* or *securiformis* which have been, as Portlock observed, crushed dorso-ventrally. In every case, the line of the umbonal ridge has proved the weakest and has produced, under pressure, a sharp keel-like appearance, described by Reed as 'acutely carinated'. It is clear that the specimens of *M. brycei* which Portlock figured and described belong to *C.?* *expansa*, while those which he described as 'young individuals' (1843, p. 426) are *C.?* *securiformis*.

Although the detail of the hinge is not well preserved, and the anterior teeth are not known, the position and appearance of the posterior lateral teeth suggests that *Cyrtodonta* is the appropriate genus for both *expansa* and *securiformis* but in the absence of the anterior dentition the genus remains doubtful. The presence of the posterior teeth, which Reed (1952, p. 71) apparently interpreted as a ligament groove, precludes the assignment of either species to the edentulous *Modiolopsis* [= *Modiodesma*, = *Orthodesma* Laroque and Newell, 1969, p. N397]. However, *C.?* *expansa* bears a strong resemblance in form to *Sphenolium* sp. as figured by Pojeta (1978, pl. 8, fig. 6) which, although previously placed in synonymy with *Modiolopsis* (as in the *Treatise etc.*, p. N397), Pojeta (1978, p. 235) now appears to regard as a cyrtodontid. The strongly prosocline form of *C.?* *expansa* distinguishes it from the species figured from North America by Ulrich, Pojeta, and others which, in illustration, tend to have a more rounded outline.

Cyrtodonta? *securiformis* (Portlock 1843)

Plate 11, figs. 5-7, 10, 12-14

- v* *pars.* 1843 *Modiola expansa* Portlock, p. 425 [*pars.*: smaller variety].
- v* 1843 *Modiola securiformis* Portlock, p. 425, pl. 33, fig. 8.
- v* *pars.* 1843 *Modiola Brycei* Portlock, p. 425 [*pars.*: see *Cyrtodonta?* *expansa* (Portlock)].
- v. 1846 *Modiola securiformis* Portlock; McCoy, p. 18.
- 1878 *Modiolopsis securiformis* Portlock; Bailey, p. 28.
- ? *non.* 1946 *Whitella* cf. *brycei* (Portlock); Lamont, p. 366, pl. 1, figs. 1, 2.
- v* 1952 *Orthodesma tyronense* Reed, p. 71, pl. 3, fig. 17.
- v* 1952 *Whiteavesia subexpansa* Reed, p. 72, pl. 4, fig. 2.
- v* 1952 *Modiolopsis concentrica* Hall and Whitfield var. *simulans* Reed, p. 69, pl. 3, fig. 14.
- v. 1952 *Modiolopsis securiformis* (Portlock); Reed, p. 70, pl. 3, fig. 15.
- v. 1952 *Goniophora brycei* (Portlock); Reed, p. 78 [*pars.*: see *Cyrtodonta?* *expansa* (Portlock)].

Type-specimens. Lectotype of *Modiola securiformis* here selected, IGS GSM 12448, Portlock's figured specimen: paralectotype IGS GSM 12449. Type of *M. brycei*: see *Cyrtodonta? expansa* (Portlock). Holotype of *Orthodesma tyronense* IGS GSM 12447 by original designation of Reed (1952, p. 72). Holotype of *Whiteavesia subexpansa* IGS GSM 12446 by original designation of Reed (1952, p. 73). Holotype of *Modiolopsis concentrica simulans* Reed SM A16294a,b by original designation of Reed (1952, p. 70). All from the Bardahessiagh Formation, Pomeroy, Co. Tyrone, exact localities uncertain, south of Craighardahessiagh.

Material, localities, and horizon. Specimens in IGS (GSM 12446-9, 22038, 24172, GU1880, Zf1021) and UM (1920-845, K4206-4210, 4245-4246). All composite moulds, from the same locality and horizon as given above.

Measurements. Type-specimen, GSM 12448, which is compressed dorso-ventrally; for left valve, the least distorted: H 13.6 mm, L 30.7 mm, AL 8.2 mm. GSM 12446, undistorted, H 30 mm, L 35.1 mm, AL 9.7 mm.

Description. Obliquely ovate, becoming broader towards the posterior, with a height-length ratio of about 0.9, but very variable in the distorted specimens available. Maximum inflation seen in a single undistorted valve is 3.9 mm in a valve 35.6 mm long. The hinge-line is straight or very gently curved and is about half as long as the total length of the shell. At the posterior end of the hinge-line are 2+ posterior lateral teeth in the right valve and 1+ in the left, but the preservation of the material prevents accurate description. The antero-dorsal margin is curved and meets the hinge-line at an angle of about 130°. The ventral margin is almost straight. Umbones prosogyrate, placed at about the anterior quarter projecting slightly above the hinge-line. A rounded umbonal ridge extends backwards at about 50° from the hinge-line to the ventral margin at its furthest point from the umbo. The anterior teeth are unknown. The musculature is unknown. Sculpture of irregular concentric striae.

Discussion. See discussion of *C.? expansa*. Portlock (1843, p. 425) described his specimens of *Modiola securiformis* as being 'partly distorted by pressure'. In the lectotype (GSM 12448), the right valve approaches the *M. brycei* Portlock form, with the umbonal ridge becoming sharpened; the left valve is less distorted and has the form of the smaller variety of *M. expansa*. Another specimen (UM K4245) shows two sets of distorted conjoined valves lying on the same plane, oriented at about 45° to each other. In each the left valve is *brycei*-like in form, while the right valve retains its shape with perhaps a reduction in height and an accentuation of the umbonal ridge. Reed's (1952) species *O. tyronense* and *W. subexpansa* are here interpreted as almost undistorted valves of *C.? securiformis*. The types (GSM 12446-12447) are so alike, apart from being opposite valves, that it is hard to understand why Reed separated them specifically, let alone generically. Portlock's 'younger individuals' of *M. brycei* are badly distorted *C.? securiformis*.

The reasons for referring *securiformis* to '*Cyrtodonta?*' are discussed under *C.? expansa*. While it is possible that *C.? expansa* and *C.? securiformis* may be synonymous, there are clear differences between them: *securiformis* is noticeably more truncate posteriorly in appearance, its postero-dorsal margin meeting the hinge-line at a steeper angle than in *expansa*, and its umbones being relatively more posterior.

Reed's (1952) *Modiolopsis concentrica simulans* seems to be a specimen of *C.? securiformis* which, as a result of distortion, is higher and shorter than normal. Hind's figure of *C. transversa* (1910, pl. 4, figs. 19, 19a, ?20) from the Drummuck Group (Ashgill) closely resembles *C.? securiformis*, but his specimen (BM L49860) is more inflated and slightly more prosocline than *securiformis*. The specimen from the Drummuck Group figured by Lamont (1946, pl. 1, figs. 1, 2) as *Whitella* cf. *brycei* (Portlock) should be compared with *C. transversa* rather than with *C.? securiformis*.

Cyrtodonta? sp.

Plate 13, fig. 1

- v. ?1843 *Avicula orbicularis* J. de C. Sowerby in Murchison; Portlock, pp. 425, 755 (Synoptical Table) [pars: see *Cycloconcha? speciosa* (McCoy)].

Material, horizon, and locality. A single right valve, UM K4194 from the Bardahessiagh Formation, exact locality uncertain but south of Craighardahessiagh, Pomeroy.

Measurements. L 26.2 mm, H 24.5 mm, AL 2.4 mm, inflation of the single valve 3.0 mm, obliquity 40°.

Description. Subcircular with the umbo at about the anterior one-tenth. Umbo incomplete. Obliquity of valve about 40°. The antero-dorsal margin meets the postero-dorsal margin at an angle of about 135°. Dentition poorly preserved but two parallel posterior lateral teeth are suggested by faint grooves; anterior teeth unknown. Anterior muscle scar faint, lying about half-way between the dorsal and ventral margins; posterior musculature unknown. Sculpture of fine concentric striae visible close to the anterior margin, and faint traces of a coarser concentric ornament ventrally.

Discussion. Although no Portlock label remains associated with this specimen it is almost certainly one which he likened to *Avicula orbicularis* Sowerby in Murchison 1839; in shape it compares quite well with the type of *A. orbicularis* (IGS Geol. Soc. Coll. 6888) but this is much larger with no visible posterior lateral teeth. Were it not for the more rounded shape, this specimen might have been placed in *?Cycloconcha speciosa*, but in that species one would expect to see three posterior lateral teeth in a right valve while in K4194 only two are apparent.

Genus *Vanuxemia* Billings, 1858

Type species. *Vanuxemia inconstans* Billings by subsequent designation of Miller 1889, from the Black River and Trenton Groups.

Vanuxemia? contorta (Portlock 1843)

Plate 13, figs. 4, 8

v* 1843 *Inoceramus contortus* Portlock, p. 422, pl. 33, fig. 5.

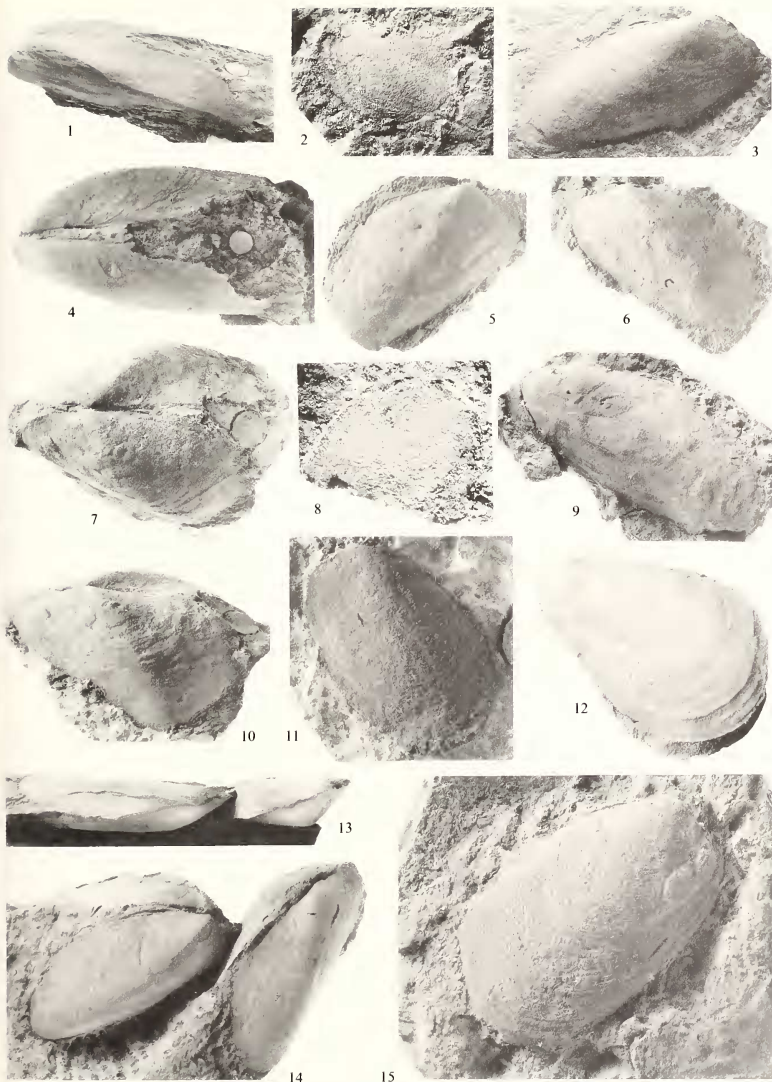
v. 1952 *Vanuxemia contorta* (Portlock); Reed, p. 68, pl. 3, fig. 12.

Type-specimen. IGS GSM 12435, holotype by monotypy; Portlock's brief description is of one shell.

Material, locality, and horizon. The type specimen (a fragmentary left valve) and a distorted right valve, IGS Zf 1020, both showing external features and both from the Killey Bridge Formation, Pomeroy, exact locality uncertain.

EXPLANATION OF PLATE II

- Figs. 1, 3, 4, 9. *Cyrtodonta? expansa* (Portlock 1843). 1, 4, conjoined valves, IGS GSM 12443, lectotype of *Modiola brycei* Portlock, 1843; 1, lateral view of left valve; 4, dorsal view of both valves. 3, right valve, UM K4247, probably the specimen figured by Baily, 1875, pl. 12, fig. 2. 9, left valve, lectotype, IGS GSM 12445. All preserved as ?composite moulds, Bardahessiagh Formation (Caradoc), south of Craigbardahessiagh, Pomeroy, $\times 1$.
- Fig. 2. Pterineid? gen. and sp. indet. ?external cast left valve IGS NIL 8981, Killey Bridge Formation (Ashgill, Cautleyan), Crocknagargan Stream section (IGR H721737), $\times 4$.
- Figs. 5-7, 10, 12-14. *Cyrtodonta? securiformis* (Portlock 1843). 5, right valve, IGS GSM 12447, holotype of *Orthodesma tyronense* Reed, 1952, $\times 1$. 6, left valve, IGS GSM 12446, holotype of *Whiteavesia subexpansa* Reed, 1952, $\times 1$. 7, 10, conjoined valves lectotype, IGS GSM 12448; 7, dorsal view, $\times 1\frac{1}{2}$; 10, lateral view of left valve, $\times 1\frac{1}{2}$. 12, external cast of left valve, SM A16294a, holotype of *Modiolopsis concentrica* var. *simulans* Reed, 1952, $\times 2$. 13, 14, slab bearing two conjoined pairs of valves, UM K4245; 13, dorsal view to show the distortion of both left valves which has produced the sharp 'umbonal ridge', leading to confusion in the past with *Goniophora*, $\times 1$; 14, lateral view of both right valves, $\times 1$. All except 12 preserved as ?composite moulds, Bardahessiagh Formation (Caradoc), south of Craigbardahessiagh, Pomeroy.
- Figs. 8, 11, 15. *Semicorallidomus?* sp. 8, latex cast of internal mould of left valve showing single small tooth, IGS GU 1739, $\times 4$. 11, composite mould of left valve, IGS GSM 12450, $\times 3$. 15, composite mould of right valve, IGS GSM 12451, $\times 3$. All Bardahessiagh Formation (Caradoc), south of Craigbardahessiagh, Pomeroy.



TUNNICLIFF, Ordovician bivalves

Measurements. Holotype incomplete. For Zf 1020 H 32.9 mm, L 25.1 mm, maximum oblique dimension 35.8 mm, apparent angle of obliquity 45 to 50°.

Description. Tall, the height being about 1.3 the length. Obliquity 45 to 50°. Length of hinge-line about half that of valve. Dentition and musculature unknown. Umbo anterior but not terminal, prosogyrate. Valve inflated to 8.7 mm in Zf 1020 after reduction by compression which has sharpened the umbonal ridge, especially towards the umbo. Sculpture of fine concentric striae, 3.5 per mm, becoming stronger towards the margin.

Discussion. Neither specimen is well preserved; the type shows only the posterior region and Zf 1020 is crushed. Portlock labelled Zf 1020 as 'indeterminate'. Reed did not use Zf 1020 when he assigned *contorta* to *Vanuxemia* with some reservation but the more complete Zf 1020, showing the anterior position of the umbones, supports his opinion. However, the nature of the material demands that the generic assignment be qualified with a ?. It is here proposed that the species be restricted to these specimens and that the species be regarded as otherwise unrecognizable.

Order PTERIOIDA Newell, 1965
Suborder PTERIINA Newell, 1965
Superfamily AMBONYCHIAE Miller, 1877
Family AMBONYCHIIDAE Miller, 1877

Remarks. In describing the ambonychiids, reference is made to Pojeta 1966, in which a terminology for certain angles and dimensions is standardized (text-fig. 7), and where a comprehensive review of North American ambonychiids is given.

Genus: AMBONYCHIA Hall, 1847

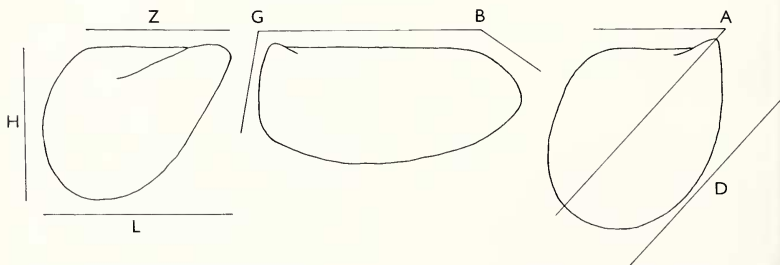
Type-species. *Ambonychia radiata* Hall, 1847, p. 163, by subsequent designation of Stoliczka (1871, p. 387).

Ambonychia arundinea sp. nov.

Plate 13, figs. 2, 3

Derivation of name. From the Latin *arundinea*, of reeds, reedy, referring both to the ornament and by allusion to F. R. C. Reed.

- v. 1843 *Uncites gryphus* Schlotheim var.; Portlock, p. 455, pl. 25A, fig. 8.
- . 1878 *Ambonychia gryphus*; Bailly, p. 28.
- v. pars. 1910 *Byssonychia radiata* Hall; Hind, p. 487, pl. 1, figs. 20, 21, non figs. 19, 22.
- v. 1952 *Byssonychia gryphus* (Portlock); Reed, p. 77.



TEXT-FIG. 7. Linear and angular measurements used in describing Ambonychiids, after Pojeta, 1966. A—angle alpha, B—angle beta, G—angle gamma, L—length, H—height, D—greatest dimension, Z—length of hinge.

Type-specimens. Holotype, right valve IGS GSM 24302. Paratypes, left valves IGS GSM 24303, BM LL 40004, right valves IGS GU 1452, 1566–1567 (counterparts), and UM 1920–835 (larger specimen). All external moulds from the Killey Bridge Formation of Pomeroy, Co. Tyrone. GSM 24302, 24303 and UM 1920–835 are not precisely localized but probably come from locality 3 of Mitchell (1977), the Little River section (Irish grid ref. H7297 7268), the locality for GU 1566–1567, GU 1452 and BM LL 40004 are from locality 2 of Mitchell, Warren Wood River section (Irish grid ref. H7130 7128).

Description. Tall subrectangular *Ambonychia*. The greatest dimension at an angle of 50 to 55° to the hinge-line. Length about 0.7 of the greatest dimension and height about 1.25 the length. The hinge length is 0.4 of the length. Greatest inflation of a single valve seen is 4 mm in a valve 33 mm high (UM 1920–835). Procline, with an angle gamma of 80 to 85°. Umbones not rounded but carinate in the sense of Pojeta 1962 (i.e. the anterior portion of the valve is flattened antero-posteriorly), and projecting between 1.4 mm and 3.0 mm above the hinge-line. Valve surface mainly gently convex. The nature of the byssal gape is not discernible but the byssal sinus is shallow. Dentition unknown although what may be the damaged remains of the posterior laterals (? in right valve) are visible in GSM 24302. The ligament area is damaged or obscured in all the present specimens and none shows musculature. About forty costae (range seen 33+, 37+, 40, 41, 43).

Discussion. Portlock briefly described his specimens (GSM 24302, 24303) as brachiopods. Hind examined Portlock's specimens and assigned them, *in museo* to *Byssonychia*, as noted by Reed (1952, p. 78) who gave the first full description, but had only these two specimens before him. He discussed the similarity and differences between these specimens and those *Byssonychia* described from Girvan by Hind (1910, p. 487, pl. 19) and other species from North America. However, he chose to retain the specific name *gryphus*, and wrongly attributed its authorship to Portlock.

The North American Richmondian species *Byssonychia richmondensis* Ulrich, and *B. robusta* (Miller), as described by Pojeta 1962, and subsequently (Pojeta 1966) transferred to *Ambonychia*, have similar numbers of costae and similar dimensions to the Pomeroy specimens, but the Irish species has a more elongate appearance, the ratio of its length to its greatest dimension is 0.7 while for *Ambonychia richmondensis* and *A. robusta* it is 0.5–0.6 and 0.6–0.75 respectively (based on Pojeta's figures). Both the American species tend more towards the acline form by about 10°.

Of Hind's figures (1910, pl. 1, figs. 19–22) of *B. radiata*, which Pojeta (1962, p. 184) excluded from *B. radiata*, figs. 19, 22 are comparable to the Richmondian species *B. suberecta* Ulrich, but figs. 20, 21 (BM L49766–49767) are close in all respects to *A. arundinea* but have a slightly higher number of costae (44 to 48).

Genus CLEIONYCHIA Ulrich, 1892

Type species. By original designation *Ambonychia lamellosa* Hall, 1862.

Cleionychia transversa (Portlock 1843)

Plate 12, figs. 1–6

- v* 1843 *Inoceramus transversus* Portlock, p. 423, pl. 33, fig. 11.
- v pars. 1843 *Inoceramus vetustus* (J. de C. Sowerby) Var. *priscus* Portlock, p. 423, pl. 33, figs. 2, 3, *non* fig. 1.
- v. 1952 *Cleionychia subovalis* Reed, p. 76, pl. 4, fig. 7.
- v. 1952 *Cleionychia subquadrata* Reed, pp. 76–77, pl. 4, fig. 8.

Type specimens. Lectotype of *Cleionychia transversa* IGS GSM 12439, selected by Reed 1952, p. 77; holotype of *C. subovalis* Reed IGS GSM 12436 by original designation; lectotype of *C. subquadrata* Reed here selected, IGS GSM 12437, the specimen figured by Reed (1952, pl. 4, fig. 8). Paralectotypes of *transversa* IGS GSM 12440, UM K4199, all from the Portlock Collection; paralectotype of *C. subquadrata* IGS GSM 24304, from the Wyatt–Edgell Collection.

Other material. IGS GSM 24305, from the Wyatt–Edgell Collection.

Horizon and locality. All from the Bardahessiagh Formation, exact locality uncertain but south of Craighardahessiagh, Pomeroy.

Measurements. For the lectotype IGS GSM 12439, L 67.6 + mm, H 40.1 mm, maximum inflation of the single valve 9.8 mm.

Description. Transversely elongate becoming relatively longer with increased size and with height about 0.6 of the length in large specimens. Inflation greatest below and slightly posterior to the umbo, gradually diminishing towards the back. Prosogyrate umbo anterior and almost terminal and rising above the hinge-line. Straight hinge-line about two-thirds of the valve length with duplivincular ligament area extending along dorsal margin. Anterior end truncate, angle gamma about 90°. Anterior slope meets commissure at about 90° but may form a distinctly obtuse angle in distorted specimens. Ventral margin curving rapidly up to anterior margin and more gently towards the posterior margin which is unclear in all the larger specimens available, but rounded and continuous with the ventral margin in smaller specimens. Angle beta about 140°. Musculature and dentition unknown. Sculpture of coarse concentric rugae, undulating in section.

Discussion. It is likely that the specimens on which Reed based his species *C. subovalis* and *C. subquadrata* (1952, pp. 76-77) are juveniles of *C. transversa*. This is supported by measurement of appropriate early growth stages of clear examples of *C. transversa*. It is found that the height to length ratio decreases from about 0.9 at 25 mm long growth stage to 0.6 at 60 mm.

Early growth stages of *C. transversa* closely resemble *C. undata* Emmons, but the latter has a slightly more acute angle gamma (apparently about 85° in Pojeta's illustrations, 1966, pl. 34, figs. 1-5) and there are no figures of late growth stages comparable to those seen in *C. transversa*.

Cleionychia prisca (Portlock 1843)

Plate 12, figs. 8, 12

- v* pars. 1843 *Inoceramus vetustus* (J. de C. Sowerby) Var. *priscus* Portlock, p. 423, pl. 33, fig. 1, non figs. 2, 3.
 . 1878 *Ambonychia undata* Hall; Bailly, p. 28.
 v. 1952 *Ambonychia prisca* (Portlock); Reed, p. 73.

EXPLANATION OF PLATE 12

- Figs. 1-6. *Cleionychia transversa* (Portlock 1843). 1, left valve, lectotype, IGS GSM 12439. 2, left valve, UM K4199. 3, right valve, IGS GSM 12436, holotype of *Cleionychia subovalis* Reed, 1952. 4, right valve, IGS GSM 12440. 5, left valve, IGS GSM 12437, lectotype of *Cleionychia subquadrata* Reed, 1952. 6, left valve, IGS GSM 24304. All external casts, Bardahessiagh Formation (Caradoc), south of Craighardahessiagh, Pomeroy, $\times 1$.
 Figs. 7, 11, 13. *Cleionychia incognita* sp. nov. 7, right valve, IGS GSM 24310. 11, left valve, holotype, IGS GSM 12441; note the bryozoan of the type referred by Portlock (1843, p. 360) to *Entobia antiqua* Portlock. 13, small left valve, IGS GSM 24311. All external casts, Bardahessiagh Formation (Caradoc), south of Craighardahessiagh, $\times 1\frac{1}{2}$.
 Figs. 8, 12. *Cleionychia prisca* (Portlock 1843). 8, right valve, UM K4200. 12, right valve, lectotype, IGS GSM 12438. Both external casts, Bardahessiagh Formation (Caradoc), south of Craighardahessiagh, Pomeroy, $\times 1$.
 Fig. 9. *Corallidomus concentrica* (Hall and Whitfield 1875), ?composite mould right valve, UM 1920-843, Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 2$.
 Fig. 10. *Corallidomus*? sp. ?external cast of right valve, NMI G.4. 1979, Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 2$.
 Fig. 14. *Ambonychiopsis suspecta* (Reed 1952), ?composite mould of left valve, holotype, IGS GSM 22103, Bardahessiagh Formation (Caradoc), south of Craighardahessiagh, $\times 1$.
 Fig. 15. *Goniophora* sp., external cast of right valve, IGS Zs 2751, Killey Bridge Formation (Ashgill, Cautleyan), locality 3 of Mitchell 1977 (IGR H7297 7268), $\times 4$.



TUNNICLIFF, Ordovician bivalves

Type-specimens, horizon, and localities. Lectotype IGS GSM 12438, right valve, (with a second valve only partly visible) selected by Reed 1952, p. 74; paralectotype (not known to Reed) UM K4200. Both from the Bardahessiagh Formation from Portlock's locality 'sheet 37 no. 6' south of Craigbardahessiagh, Pomeroy.

Other material. A single specimen in the Griffith Collection, NMI; locality and horizon as for the type specimens.

Measurements. For the lectotype, L 66.5 + mm, H 60.2 + mm, maximum inflation of the single valve 12.2 mm, greatest dimension (oblique) 74.1 mm, angle alpha c. 55°, angle gamma c. 85°, angle beta c. 120°, length of hinge uncertain, height of umbo above hinge-line 8 mm.

Description. Obliquely ovate form, narrow anteriorly and expanding rapidly towards the posterior end. Height about 0.9 of length; precise length and detail of hinge-line unknown. Greatest dimension approximately 1.25 times length; angle alpha about 50°, angle gamma about 80 to 85°, angle beta about 120°. Maximum inflation seen in a single valve, in the lectotype 12.2 mm. Umbo terminal. Antero-ventral slope steep, meeting the plane of commissure at an angle of 90 to 100°. Posterior surface convex, becoming flatter towards the posterior end. Ligament, musculature, and dentition unknown. Sculpture of coarse concentric rugae undulating in section, about 2 per 10 mm along the plane of the greatest dimension.

Discussion. Although not well preserved, the specimens of *Cleionychia prisca* (Portlock) are sufficiently distinct to be separated from *C. transversa* and *C. incognita* sp. nov. While the sculpture in *C. prisca* is very like that in *C. transversa*, angle gamma is more acute in *C. prisca* and the shell has a generally more oblique and inflated appearance. Angle alpha in *C. prisca* is less acute than in *C. incognita* which lacks the strong concentric rugae of *C. prisca*.

Pojeta (1966, pp. 177, 180) pointed out that Reed's figures were poor and that it was not clear (despite his comments, 1952, p. 74) how Reed distinguished *Cleionychia* spp. from *Ambonychia* spp. None of the specimens which Reed assigned to *Cleionychia* is greatly inflated but they have concentric undulating sculpture; those which he placed in *Ambonychia* Isberg are more inflated, elongate obliquely, and have prominent umbones and a more acute angle gamma, but while having concentric ornament they apparently lack the radial costellae diagnostic of *Ambonychiopsis* Isberg although in shape they resemble the latter. The specimens treated by Reed as *Ambonychia* are here assigned to *Cleionychia* following the suggestion inherent in Pojeta's remarks (1966, p. 177).

Reed (1952, p. 74) pointed out the similarity of *C. prisca* to one of Isberg's (1934, pl. 4, fig. 6) figures of *Ambonychia corrugata* (Lindström) and also noted the different appearance of the remaining figures of *A. corrugata* (Isberg 1934, pl. 4, figs. 1-5, 7). The specimen in Isberg's pl. 4, fig. 6 appears to have stronger rugae than seen in *C. prisca* and each of its angles alpha, beta, and gamma is a little more acute than seen in *C. prisca*.

Cleionychia incognita sp. nov.

Plate 12, figs. 7, 11, 13

Derivation of name. From the Latin *incognita* unknown or unrecognized, referring to the nomenclatorial history of the type specimens.

- v. 1843 *Inoceramus trigonus* (Münster); Portlock, p. 422, pl. 33, figs. 4, 4a.
- . 1878 *Ambonychia trigona* Portlock; Baily, p. 28.
- v. 1952 *Ambonychia* cf. *amygdalina* (Hall); Reed, p. 75, pl. 4, fig. 5.
- v. 1952 *Ambonychia* cf. *intermedia* Isberg; Reed, p. 75, pl. 4, fig. 6.
- v. 1952 *Ambonychia* cf. *volvans* Isberg; Reed, p. 74, pl. 4, fig. 4.

Type specimens. Holotype IGS GSM 12441, a left valve, figured by Portlock 1843, pl. 33, fig. 4; paratypes IGS GSM 24310, 24311 from the Wyatt-Edgell Collection, a right and a small left valve and IGS GSM 24306, 24307, 104237, three distorted specimens showing conjoined valves, all from the Wyatt-Edgell Collection.

Horizon and localities. Bardahessiagh Formation, exact localities uncertain but south of Craigbardahessiagh, Pomeroy.

Measurements. For the holotype, L 41.4 mm, H 34.7 mm, greatest dimension (oblique) 49.3+ mm, angle alpha c. 40°, angle gamma 75°, angle beta c. 120°, maximum inflation of the single valve 11.5 mm, length of hinge 29.6+ mm.

Description. Obliquely ovate to subquadrate in form, narrow anteriorly and expanding rapidly towards the posterior end. Height about 0.8 to 0.9 of length. Straight hinge-line about 0.7 to 0.75 length. Greatest dimension approximately 1.1 to 1.2 times length; angle alpha 40 to 50°. Angle gamma 70 to 80°, angle beta 115 to 135°. Maximum inflation of a single valve seen 11.5 mm in the holotype. Umbo terminal, rising above the hinge-line. Antero-ventral slope steep, meeting the plane of commissure at an angle of about 100° but varying with size and distortion of specimen. Posterior surface convex, becoming flatter towards the posterior end and with a plano-concave dorsal area below the hinge-line. Ligament, musculature, and dentition unknown. Sculpture of faint indistinct concentric lines and faint coarser rugae visible particularly on the antero-ventral surface.

Discussion. *Cleionychia incognita* is distinct from *C. transversa* and *C. prisca* in lacking the coarse rugae seen over the whole surface in those species. It is less transverse than *C. transversa* and less oblique than *C. prisca* which it closely resembles in general form but which does not show the flattened dorsal area seen in *C. incognita*.

Reed (1952, p. 75) compared IGS GSM 24310 with Hall's *Ambonychia amygdalina* and placed it in Isberg's genus *Ambonychia*. Pojeta (1966, p. 163) has described *amygdalina* as belonging to *Ambonychiopsis* Isberg. None of the present specimens of *C. incognita* shows the radial ornament or anterior lobe associated with *Ambonychiopsis*. *Ambonychia intermedia* Isberg, with which Reed (1952, p. 75) compared IGS GSM 12441 does bear a close resemblance to *C. incognita* but Isberg's figure (1934, pl. 9, fig. 1) shows more obtuse angles gamma (c. 90°) and beta (?140°) than seen in *C. incognita*. Similarly, there is a recognizable similarity between IGS GSM 24311 and *A. volvens* Isberg with which Reed (1952, p. 74) compared it, but *A. volvens* appears to have a small anterior lobe (Isberg 1934, pl. 2, fig. 4c) not seen in *C. incognita*. The flattened postero-dorsal area is not so pronounced in other species of *Cleionychia* except perhaps *C. intermedia*. The use of the generic name *Cleionychia* rather than *Ambonychia* is discussed under *C. prisca*.

Genus AMBONYCHIPSIS Isberg, 1934

Type-species. By original designation of Isberg 1934, p. 82, *Ambonychiopsis osmundsbergensis*.

Ambonychiopsis suspecta (Reed 1952)

Plate 12, fig. 14

v* 1952 *Vanuxemia?* *suspecta* Reed, p. 69, pl. 3, fig. 13.

Type specimen, horizon, and locality. Holotype by monotypy IGS GSM 22103, by original designation of Reed 1952, p. 69; a ?composite mould of a left valve, the only known specimen, from the Bardahessiagh Formation, exact locality uncertain, but south of Craighbardahessiagh, Pomeroy.

Measurements. For the monotype L 26.9 mm, H 19.8 mm, greatest dimension (oblique) 29.1 mm, angle alpha c. 35°, angle gamma 60°, angle beta 150°, maximum inflation of the single valve c. 3 mm, length of hinge-line 17.9 mm.

Description. The specimen is lacking in detail but shows an obliquely ovate form, very narrow anteriorly and expanding rapidly towards the posterior end. Height is 0.7 of the length, hinge-line is 0.6 of the length and is apparently straight. The greatest dimension, along the plane of obliquity 35° to the hinge-line, is 1.1 times the length. Angles gamma and beta and inflation are given above. Anterior to the otherwise terminal umbo is a small anterior lobe. The posterior surface is gently convex. The steep antero-ventral slope meets the plane of commissure at an angle of about 60°. Ligament and musculature unknown. Dentition represented only by two doubtful posterior lateral grooves below and anterior to the postero-dorsal angle of the margin. Sculpture is poorly preserved and shows only irregular concentric striae.

Discussion. Portlock labelled this specimen '*Mytilus?*—not specifically determined'. Reed described two to three short cardinal teeth anterior to the umbo but these are not evident. The specimen has been developed a little since Reed examined it and part of the small anterior lobe now revealed

may have led Reed to his conclusions and suggested to him his determination *Vanuxemia? suspecta*. His use of a query (?) and the name *suspecta* both suggest that Reed remained doubtful as to the nature of this specimen. Some doubt is retained in applying the generic name *Ambonychiopsis* to *suspecta* but this assignment is justified by the ambonychiid nature of the form and sculpture, and the presence of the anterior lobe. However, there is a lack of the radial sculpture characteristic of *Ambonychiopsis*.

Ambonychinia balclatchiensis Reed (1944, p. 213, pl. 2, fig. 2) from the Balclatchie Beds is probably an *Ambonychiopsis*: the illustration shows an anterior lobe, oriented such that it appears to be dorsal. Angles alpha (c. 30°), beta (c. 150°), and gamma (c. 70°) in Reed's figure are close to those of *A. suspecta* and its greatest dimension is 1.03 of its length (1.1 in *A. suspecta*), but the anterior lobe in *A. balclatchiensis* is larger.

The preservation of the specimen is such that comparison with other species presents great difficulty. It is here proposed that the name be restricted to the type specimen and the species be regarded as otherwise unrecognizable.

pterineid? gen. and sp. indet.

Plate 11, fig. 2

A single, very small specimen (IGS NIL 8981) from the Killey Bridge Formation of the Crocknagargan Stream section (Irish grid ref. H721737), is probably a pterineid. Although poorly preserved, it can be compared in outline and size to *Palaeopteria parvula* Whiteaves (1897, p. 181, pl. 20, figs. 1-3), from rocks of Black River-Trenton age (Caradoc) in the area of Lake Winnipeg. *Pterinea reticulata* Hind (1910, p. 494, pl. 1, figs. 7-8) from the Drummuck Group of Girvan has a distinctive ornament and is larger than the Irish specimen.

bivalve? gen. and sp. indet.

Plate 13, fig. 7

Material, horizon, and locality. A single specimen, IGS GSM 24308, from the Bardahessiagh Formation, exact locality unknown, south of Craigbardahessiagh, Pomeroy.

Description. A subtriangular fragment measuring 40.0 by 30.7 mm and showing 19+ coarse concentric rugae.

Discussion. This fragmentary specimen has in the past been referred plausibly to *Ambonychia undata* Hall, and indeed the coarse ornament on the specimen bears some resemblance to Hall's figure (1847, pl. 36, fig. 7a). It is considered, on the ornament alone, to resemble *Cleionychia*, but this view gives rise to difficulties of interpretation and a gastropod or cephalopod affinity is more probable. No comparable material is known from Pomeroy.

Subclass ISOFILIBRANCHIA Iredale, 1939
Order MYTILOIDA Ferussac, 1822
Superfamily MYTILACEA Rafinesque, 1815
Family MODIOLOPSIDAE Fischer, 1887
(after Pojeta and Gilbert-Tomlinson, 1978)
Genus MODIOLOPSIS Hall, 1847

Type species. *Pterinea modiolaris* Conrad, 1838, by original designation of Hall 1847, p. 157.

Modiolopsis sp.

Plate 13, fig. 11

Material, horizon, and locality. A single, fragmentary, small internal mould of a right valve, IGS GU 1380, from the Killey Bridge Formation at the Crocknagargan Stream section (locality 1 of Mitchell 1977), Pomeroy, Co. Tyrone.

Description. Elongate, obliquely ovate, modioliform, with the umbo at about the anterior one-tenth to one-fifth. Height (12.5 + mm), about half of length (26.0 + mm). Inflation of the single valve 2.5 mm. The incomplete anterior end is narrow but the shell broadens rapidly towards the flat posterior which is also incomplete. The ventral slope and margin show a slight sinus a little posterior to the umbo. A rounded umbonal ridge runs towards the postero-ventral angle which is lost. An adductor muscle scar occupies much of the preumbonal portion of the shell and two umbonal muscle scars are present. Edentulous but with a dorsal longitudinal groove. Sculpture unknown except for a suggestion of concentric ornament on the antero-ventral slope.

Discussion. Although fragmentary, this specimen is similar in shape to two species figured by Hind (1910): *Modiolopsis exasperatus* (Phillips) (Hind 1910, pl. 2, fig. 15) and *M. scotica* Hind (1910, pl. 2, figs. 18–20) both recorded from the Drummuck Group (Ashgill) of Girvan. In both the Scottish species the valves become higher very rapidly towards the posterior as in the Irish specimen, but although the latter is incomplete, its postero-dorsal margin suggests that it is less elongate.

Genus *CORALLIDOMUS* Whitfield, 1895

Type species. *C. concentrica* (Hall and Whitfield 1875), by monotypy: the only Ordovician species assigned to the genus (Pojeta 1971, p. 6).

Corallidomus concentrica (Hall and Whitfield 1875)

Plate 12, fig. 9

- * 1875 *Modiolopsis concentrica* Hall and Whitfield, pp. 86–87, pl. 2, fig. 18.
- 1893 [1895] *Corallidomus concentricus* Whitfield, pp. 492–493, pl. 13, fig. 2 [on p. 493], pl. 13, [as n. gen., n. sp.].
- 1978 *Corallidomus concentrica* (Hall and Whitfield); Pojeta, pl. 12, figs. 12–14.

Material, horizon, and locality. A right valve, UM 1920–843, from the Killeen Bridge Formation of Pomeroy, Co. Tyrone, exact locality uncertain.

Description. A small modioliform shell, nearly twice as long as high (12 mm high, 22 mm long) and inflated to nearly 2 mm at one point along the umbonal ridge. The shell broadens towards the posterior. The anterior margin is rounded, the posterior end is obliquely truncate. The ventral margin shows a slight flexure at about the mid-point. The umbo lies at about the anterior one-quarter. The preumbonal part of the shell is occupied by an adductor muscle scar. Dentition uncertain but there is a suggestion of a short, thin, posterior tooth immediately behind the umbo. The ornament is distinctive: the antero-ventral portion of the shell bears fine concentric lines which give way at the umbonal ridge to strong, coarse, fairly regular concentric rugae. The umbonal ridge becomes less marked away from the umbo but is defined by the change in texture and direction of the ornament.

Discussion. The specimen closely matches the descriptions and illustrations of Hall and Whitfield (1875, pp. 86–87, pl. 2, fig. 18) and the specimens figured by Pojeta (1978, pl. 12, figs. 12–14). Pojeta (1978, pl. 12, figs. 12–14) figured *Modiolopsis concentrica* as *Corallidomus concentrica*, treating it as synonymous with Whitfield's type species, and is followed here; however, Whitfield's (1893) figures and the lack of his material (Pojeta 1971, p. 30) do give rise to some doubt as to whether the two species are identical and therefore whether *M. concentrica* should be assigned to *Corallidomus*. Pojeta (1971, pp. 30–33) observed that the known occurrence of *Corallidomus* is restricted to the Richmondian, comparable to the Cautleyan age of the Killeen Bridge Formation. The mode of life of *Corallidomus*, recorded by Whitfield as boring into masses of the coral *Labechia ohioensis*, is said by Pojeta (1971) to be unique among Ordovician bivalves and, although the present specimen is not in life position, it is worth noting that masses of the tabulate coral *Catenipora tapaensis* (Sokolov) [identified by Dr. D. E. White, IGS] were collected by Portlock (IGS GSM 103460, 104183, 104184) from the Killeen Bridge Formation, possibly from locality 3 of Mitchell 1977.

A left valve, NMI G.4. 1979, in the Griffith Collection is from the same horizon as UM 1920 843 but also lacks exact locality details and is here recorded as *Corallidomus?* sp. (Pl. 12, fig. 10). It lacks the characteristic coarser ornament on the posterior portion of the shell and has a more central umbo than *C. concentrica*.

Subclass PALAEOHETERODONTA Newell, 1965
 Order MODIOMORPHOIDEA Newell, 1969
 Superfamily MODIOMORPHACEA Miller, 1877
 Family MODIOMORPHIDAE Miller, 1877
 Genus GONIOPHORA Phillips, 1848

Type species. *Goniophora cymbaeformis* (J. de C. Sowerby) by original designation of Phillips 1848, p. 264.

Goniophora sp.

Plate 12, fig. 15

Material, locality, and horizon. A single specimen, IGS Zs 2751, external cast of a right valve collected by Mr. R. P. Tripp from the Killey Bridge Formation, at locality 3 of Mitchell (1977), the Little River Section (Irish grid ref. H7297 7268).

Measurements. H 6.0 mm, L 13.8 mm, AL 2.8 mm; inflation of the single valve 1.8 mm; obliquity, measured along umbonal ridge, 35–40°.

Description. Small *Goniophora*; transversely elongate with a pronounced, slightly sigmoidal umbonal ridge or carina running from the umbo to the postero-ventral angle; height to length ratio 0.43; umbo barely protruding above the hinge-line and situated at about the anterior one-fifth. Dentition and musculature unknown. The surface anterior to the carina shows concentric striae of irregular strength and spacing but the posterior surface has a well-developed concentric sculpture, regularly spaced, with 3–4 striae per mm. The posterior surface also shows a flexure close behind the carina.

Discussion. This remains the only known *Goniophora* specimen from the Ordovician of Pomeroy: *Goniophora brycei* (Portlock) of Reed (1952, p. 78) is a *Cyrtodonta*? (see *Cyrtodonta*? spp.). In the absence of any detail of the hinge, there is some doubt as to whether *Goniophora* or *Goniophorina* Isberg is the more appropriate genus for this specimen; but it is reasonable to place it in the more familiar *Goniophora*. The lack of radial costae precludes it from being *Cosmogoniophora* McLearn.

Specimens of a comparable form from Caradocian rocks in north Wales are under study.

Genus COLPOMYA Ulrich, 1894

Type species. Monotype, *Colpomya constricta* Ulrich by original designation of Ulrich 1894, pp. 522–523.

Colpomya simplex (Portlock 1843)

Plate 13, fig. 14

- v* 1843 *Cypricardia? simplex* Portlock, p. 426.
- v pars. 1910 *Grammysia undata* J. de C. Sowerby; Hind, p. 540, pl. 5, fig. 14, ?non figs. 13, 15, 16.
- v. 1952 *Cuneamya simplex* (Portlock); Reed, p. 79, pl. 4, fig. 10.

Type-specimen. The only known syntype, a left valve, IGS GSM 24290, from the Killey Bridge Formation, is here selected as lectotype; locality given by Portlock as his 'sheet 37 no. 2', probably locality 3 of Mitchell (1977), the Little River section, Pomeroy (Irish grid ref. H7297 7268).

Measurements. H 22.9 mm, L 39.5 mm, AL 14.00 mm, inflation of the single valve is 7.8 mm; obliquity, measured along the umbonal ridge, 35°.

Description. Transversely elongate, rounded at posterior and anterior ends, with dorsal and ventral margins subparallel; posterior broader than anterior. The height is about 0.6 of the length and the umbo is at about the anterior one-third. The single valve is inflated to 7.8 mm in the type-specimen. A slightly sigmoidal rounded umbonal ridge at an angle of 35° to the hinge-line meets the postero-ventral margin below the posterior end of the hinge-line. The prosogyrate umbo extends above the hinge-line and is flattened, the flat area corresponding to the very faint sulcus developed towards the margin anterior to the umbonal ridge. Lunule present but

escutcheon not clearly differentiated. Dentition and musculature unknown. Sculpture of coarse, rather irregular concentric rugae, pronounced anterior to the sulcus and becoming fainter and even indistinguishable on the posterior surface.

Discussion. Portlock (1843, p. 426) and Hind (MS, see Reed 1952, p. 79) compared this species to *Cypricardia impressa* J. de C. Sowerby (in Murchison). As Portlock observed, the sulcus in *C. simplex* is much less pronounced than in *C. impressa*. *Colpomya simplex* differs from *Cuneamya* in that the umbo is not terminal (cf. *Cuneamya miamiensis* Hall and Whitfield as figured in the *Treatise*, p. N821 and Pojeta 1971, pl. 15, figs. 9, 10), but it is closely comparable to the type species of *Colpomya*, *C. constricta* Ulrich (1894, p. 523, fig. 41) from the upper Trenton of Kentucky. The specimen figured by Hind (1910, pl. 5, fig. 14) from the Drummuck Group (BM L49889) may be conspecific with *C. simplex*.

Genus SEMICORALLIDOMUS Isberg, 1934

Type species. *Semicorallidomus whitfieldi* Isberg by original designation of Isberg 1934, pp. 175, 180 from the Ordovician of Sweden.

Semicorallidomus? sp.

Plate 11, figs. 8, 11, 15

- v. 1843 *Modiola Nerei* (Münster); Portlock, p. 424, pl. 33, fig. 10.
- v. 1843 *Mytilus? Nerei* (Münster); Portlock, p. 424.
- 1878 *Modiolopsis Nerei* Münster; Baily, p. 28.
- ? 1952 *Modiolodon speciosus* (McCoy); Reed, p. 72, pl. 4, fig. 1.
- v. 1952 *Paramodiola?* sp.; Reed, p. 73, pl. 4, fig. 3.

Material. IGS (Portlock and Mitchell collections) GSM 12450–12452, GU 1739, 1741; UM (Portlock and Grainger collections) 4125 and counterpart, K4169, 4195, 4197–4198, 4242; NMI (Griffith collection); TCD 7871 (Portlock collection); ?SM A16461.

Localities and horizon. All from the Bardahessiagh Formation, south of Craighardahessiagh, Pomeroy, exact localities uncertain.

Measurements	L	H	H/L	AL/L
Max.	20.0 mm	14.0 mm	0.85	0.15
Min.	10.0 mm	7.2 mm	0.62	0.07
Mean	14.63 mm	10.4 mm	0.71	0.11
Median	15.0 mm	10.6 mm	0.74	0.11

Description. Subovate, modiomorphoid, with a height-length ratio about 0.7. Umbo not prominent and at about the anterior one-tenth to one-fifth. Some specimens show a slight flexure of the posterior surface. Obliquity about 30°. Apparently isomyarian with the anterior adductor muscle scar almost below the umbo and the posterior scar poorly defined. Single valve inflated to about 2.5 mm in the larger specimens. Concentric ornament of varying strength, with an average of five striae per mm on the most inflated part of the shell along the plane of obliquity. Precise nature of the hinge unknown, but the left valve apparently bears a tooth below the umbo (IGS GU 1739, Pl. 11, fig. 8).

Discussion. The name *Paramodiola*, used by Reed (1952) for this form, is rejected here in view of the apparent presence of a tooth in the left valve (GU 1739); *Paramodiola* is said to be edentulous. A diagnostic characteristic of *Semicorallidomus* is the presence in the left valve of a socket, the reverse of what is seen in the Pomeroy form. In outline, the Irish specimens most closely resemble the type species *Semicorallidomus whitfieldi* Isberg. The specimen described and figured by Reed (1952, p. 72, pl. 4, fig. 1) as *Modiolodon speciosus* (McCoy) (SM A16461) was not available for study at the time of writing, but his figure resembles the known specimens of *Semicorallidomus?* McCoy's specimen of *M. speciosus* is in the NMI (see *Cycloconcha? speciosa*).

Subclass ACTINODONTIA Douvillé, 1912 (after Pojeta 1978)

Family CYCLOCONCHIDAE Ulrich, 1884

Genus CYCLOCONCHA Miller, 1874

Type species. By original designation *Cycloconcha mediocardinalis* Miller, 1874, p. 231.

Cycloconcha? speciosa (McCoy 1846)

Plate 13, figs. 5, 6, 9, 10, 12, 13

v. 1843 *Avicula obliqua* J. de C. Sowerby in Murchison; Portlock, p. 425.

v. 1843 *Avicula orbicularis* J. de C. Sowerby in Murchison; Portlock, pp. 425, 755 (Synoptical Table) [pars: see *Cyrtodonta? sp.*].

v* 1846 *Pullastra speciosa* McCoy, p. 17, pl. 2, fig. 2 (reversed).

?non 1952 *Modiolodon speciosus* (McCoy); Reed, p. 72, pl. 4, fig. 1.

Type specimen. The original of McCoy's figure (1846, pl. 2, fig. 2) is in the NMI Griffith Collection and as the only known syntype is here selected as Lectotype, NMI G.5. 1979.

Material. Five right valves; GSM 21919, 21920, 104236, UM K4213, 4214. Four left valves; GSM 104235, UM K4212, 4216 and the type specimen. All are composite moulds.

Horizon and locality. All from the Bardahessiagh Formation, exact localities uncertain but south of Craighbardahessiagh, Pomeroy.

Measurements	L	H	H/L	AL/L	Obliquity
Max.	24.2 mm	22.0 mm	0.94	0.38	55°
Min.	16.0 mm	13.0 mm	0.72	0.29	45°
Mean	22.4 mm	18.6 mm	0.83	0.34	50.6°
Median	20.1 mm	17.5 mm	0.83	0.34	50°

EXPLANATION OF PLATE 13

Fig. 1. *Cyrtodonta? sp.* ?composite mould of right valve, UM K4194, Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, Pomeroy, $\times 1\frac{1}{2}$.

Figs. 2, 3. *Ambonychia arundinea* sp. nov. 2, external cast of right valve, IGS GSM 24302. 3, external cast of left valve IGS GSM 24303. Both Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 1\frac{1}{2}$.

Figs. 4, 8. *Vanuxemia? contorta* (Portlock 1843). 4, external cast of left valve, holotype, IGS GSM 12435. 8, external cast of right valve, IGS Zf 1020. Both Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 1$.

Figs. 5, 6, 9, 10, 12, 13. *Cycloconcha? speciosa* (McCoy 1846). 5, left valve, lectotype NMI G.5. 1979. 6, right valve, UM K4214. 9, left valve, UM K4212. 10, right valve, IGS GSM 21920. 12, right valve, IGS GSM 21919. 13, left valve, UM K4216. All preserved as composite moulds, Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, Pomeroy, $\times 1\frac{1}{2}$.

Fig. 7. Bivalve? gen. and sp. indet. ?external cast IGS GSM 24308, Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, $\times 1$.

Fig. 11. *Modiolopsis* sp. internal mould of right valve, IGS GU 1380, Killey Bridge Formation (Ashgill, Cautleyan), Crocknagargan Stream section, Pomeroy (IGR H721737), $\times 2\frac{1}{2}$.

Fig. 14. *Colpomya simplex* (Portlock 1843), external cast of left valve, lectotype, IGS GSM 24290, Killey Bridge Formation (Ashgill, Cautleyan), Pomeroy, exact locality uncertain, $\times 1\frac{1}{2}$.

Figs. 15-19. *Lyrodesma radiatum* (Portlock 1843). 15, 17, left valve, internal mould, IGS GU 3264; 15, oblique dorsal view to show dentition, lit from bottom left, $\times 6$; 17, lateral view, lit from bottom left, $\times 4$. 16, external cast of left valve, lectotype, IGS GSM 22178, $\times 2$. 18, external cast of right valve, IGS GSM 22177, $\times 2$. 19, composite mould of conjoined valves, IGS GSM 104185, $\times 2$. All Bardahessiagh Formation (Caradoc), south of Craighbardahessiagh, Pomeroy.



TUNNICLIFF, Ordovician bivalves

Description. *Cycloconcha*? of slightly variable subovate shape, the posterior end being somewhat truncate, with height between 0.72 and 0.94 of the length. Slight umbonal ridge is at about 50° to the hinge-line. The anterior dorsal margin is at an angle of 145 to 155° to the posterior dorsal margin. The prosogyrate umbones are at about the anterior one-third. Maximum inflation of a single valve seen is 2 mm in a valve 24.2 mm long. Hinge-line shows two or three lamellar posterior lateral teeth in the left valve and three in the right valve, subparallel to the margin, and at least one anterior lateral tooth in each. Anterior adductor muscle scar faint, about half-way between umbo and anterior; posterior musculature unknown. Sculpture of regular concentric striae with more prominent lines at intervals of about 2.4 mm along the umbonal ridge especially towards the margin.

Discussion. This species is placed, with some reservation, in *Cycloconcha* since it possesses straight anterior and posterior teeth, although no cardinal teeth are visible in the available specimens. I have not seen Reed's specimen of *Modiolodon speciosus* (SM A16461, 1952, p. 72, pl. 4, fig. 1), and doubt whether it should be placed in *C.?* *speciosa*. Reed noted radial striation, stating that this appeared to be present in McCoy's specimen but he was working only from McCoy's figure and no radial striation is apparent in the type specimen. He also mentioned a deeply impressed anterior muscle scar but in the specimens of *C.?* *speciosa* available the anterior muscle scar can at best be described as faint. His comparison of his specimen with *Modiolopsis? consimilis* Ulrich, *Modiolodon obtusus* Ulrich, and *M. truncatus* (Hall) all suggest that we should regard his specimen as distinct from *C. speciosa*.

In shape, *C.?* *speciosa* resembles *Cyrtodonta parva* Ulrich (1894, p. 541, pl. 39, figs. 24, 25) from the Trentonian of Minnesota but it is larger and the posterior teeth are longer. In this last respect, comparison may be made with the upper Trenton shale form *Cypricardites tenellus* Ulrich (1892, p. 237) from Minnesota. The teeth in *C. tenellus*, later referred to *Cyrtodonta* by Ulrich (1894, p. 546, pl. 40, figs. 15-19), are similar in form to those of *Cycloconcha speciosa*, but only two are recorded in the right valve.

Family LYRODESMATIDAE Ulrich, 1894
Genus LYRODESMa Conrad, 1841, p. 51

Type-species. By monotypy *Lyrodesma planum* Conrad, 1841, p. 51.

Lyrodesma radiatum (Portlock 1843)

Plate 13, figs. 15-19

- v* 1843 *Nucula? radiata* Portlock, p. 430, pl. 36, fig. 11.
- v. 1846 *Nucula radiata* Portlock; McCoy, p. 19.
- 1878 *Ctenodonta radiata* Portlock; Bailey, p. 28.
- v. 1952 *Lyrodesma radiatum* (Portlock); Reed, p. 67, pl. 3, fig. 11.

Type-specimen. Lectotype selected here IGS GSM 22178, the specimen figured by Portlock (1843, pl. 36, fig. 11) and used by Reed (1952, p. 67) in his redescription.

Material, localities, and horizon. Specimens in IGS, TCD, and NMI, including six Portlock syntypes. Mostly external moulds, or composite moulds. All from the Bardahessiagh Formation, south of Craighardahessiagh, Pomeroy, exact localities uncertain except IGS GU 3264, Mitchell Collection, from Mitchell's Bardahessiagh collecting area (Mitchell 1977, p. 5).

Measurements

	L	H	H/L	AL/L	Angle between antero- and postero-dorsal margins
Max.	20.0 mm	12.6 mm	0.69	0.40	c. 150°
Min.	13.0 mm	8.0 mm	0.50	0.26	c. 125°
			compressed dorso-ventrally		
Mean	16.24 mm	9.86 mm	0.60	0.34	
Median	16.5 mm	11.0 mm	0.60	0.33	

Description. *Lyrodesma* of elongate, ovate form with height-length ratio about 0.6. Maximum inflation of a single valve is about 2 mm in a valve 20 mm long. The umbo lies at about the anterior one-third. The anterior margin is rounded, the posterior end is subtruncate and obliquely carinate. Postero-dorsal surface bearing 17+ radial striations of variable strength and arranged somewhat irregularly. Anterior portions of the surface show very faint concentric growth lines. Umbones rather small. Six radiating crenulate teeth of similar size below umbo in left valve. A faint line or ridge is seen on the internal mould running from the umbo to the ventral margin anterior to the umbonal ridge. Posterior and anterior adductor muscle scars situated dorsally, the posterior scar being a little larger than the anterior. Accessory muscle scars poorly discerned in the present specimen.

Discussion. As Reed noted (1952, pp. 67–68) Portlock's description and figure of *Lyrodesma radiatum* were poor, but Reed saw only two of the Portlock syntypes and had no specimens showing the dentition. In shape and the number of teeth, *L. radiatum* resembles *L. majus* (Ulrich) and Reed likened it to *L. cincinnatiense* Hall (of Ruedemann 1926) and to *L. poststriatum elongatum* Stewart, 1920, but until more material is available to provide further detail of the internal structure, no close comparison can be made with other species.

Class ROSTROCONCHIA Pojeta, Runnegar, Morris and Newall, 1972

Order CONOCARDIOIDEA Neumayr, 1891

Superfamily CONOCARDIAE Miller, 1889

Family HIPPOCARDIIDAE Pojeta and Runnegar, 1976

Genus HIPPOCARDIA Brown, 1843

Type species. By monotypy *Cardium hibernicum* Sowerby, 1815. The classification used here is that of Pojeta and Runnegar 1976.

Hippocardia praepristis (Reed), 1952

Plate 9, fig. 8

v* 1952 *Conocardium praepristis* Reed, p. 80, pl. 4, fig. 11.

v. 1976 *Hippocardia praepristis* (Reed); Pojeta and Runnegar, p. 76.

Type specimens. Holotype by original designation, IGS GSM 24147, the only specimen known to Reed and to the present author. The specimen is part of the Portlock Collection (Tunnicliff 1980) and bears a label reading 'Cypricardia—Analogous to *C. cymbaeformis* but differs from it and also from *Cardium carpo-morphum* (J. P.)' but Portlock (1843) published no reference to it.

Locality and horizon. The horizon of this specimen is uncertain, but Reed likened the matrix to that of the Tirnaskea Beds (Tirnaskea Formation). If this is correct, a likely locality would be the Tirnaskea Stream section or perhaps the Crocknagargan Stream section, both of which have exposures of Tirnaskea Formation (Ashgill, Hirnantian) but there is no record of Portlock having specimens from the latter and there is evidence that he had none from the Tirnaskea Stream section (Portlock 1843, p. 230 '...on the Tirnaskea or small river there are thin calcareous layers of three or four inches thick mixed with quartzose bands, no fossils, however, occurring in them...'). Lithologically, the specimen resembles known Killey Bridge Formation specimens, and it must be assumed that the specimen is from that horizon, but the locality is unknown.

Description. Adequate description is provided by Reed (1952), and Pojeta and Runnegar (1976) placed *praepristis* in *Hippocardia* on this basis. The specimen is figured here to supplement Pojeta and Runnegar.

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